

Python[®]

Notes for Professionals



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About

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Chapter 1: Getting started with Python Language

Python 3.x

Version Release Date

3.8	2020-04-29
3.7	2018-06-27
3.6	2016-12-23
3.5	2015-09-13
3.4	2014-03-17
3.3	2012-09-29
3.2	2011-02-20
3.1	2009-06-26
3.0	2008-12-03

Python 2.x

Version Release Date

2.7	2010-07-03
2.6	2008-10-02
2.5	2006-09-19
2.4	2004-11-30
2.3	2003-07-29
2.2	2001-12-21
2.1	2001-04-15
2.0	2000-10-16

Section 1.1: Getting Started

Python is a widely used high-level programming language for general-purpose programming, created by Guido van Rossum and first released in 1991. Python features a dynamic type system and automatic memory management and supports multiple programming paradigms, including object-oriented, imperative, functional programming, and procedural styles. It has a large and comprehensive standard library.

Two major versions of Python are currently in active use:

- Python 3.x is the current version and is under active development.
- Python 2.x is the legacy version and will receive only security updates until 2020. No new features will be implemented. Note that many projects still use Python 2, although migrating to Python 3 is getting easier.

You can download and install either version of Python [here](#). See Python 3 vs. Python 2 for a comparison between them. In addition, some third-parties offer re-packaged versions of Python that add commonly used libraries and other features to ease setup for common use cases, such as math, data analysis or scientific use. See [the list at the official site](#).

Verify if Python is installed

To confirm that Python was installed correctly, you can verify that by running the following command in your favorite terminal (If you are using Windows OS, you need to add path of python to the environment variable before using it in command prompt):

```
$ python --version
```

Python 3.x Version \geq 3.0

If you have *Python 3* installed, and it is your default version (see **Troubleshooting** for more details) you should see something like this:

```
$ python --version
```

```
Python 3.6.0
```

Python 2.x Version \leq 2.7

If you have *Python 2* installed, and it is your default version (see **Troubleshooting** for more details) you should see something like this:

```
$ python --version
```

```
Python 2.7.13
```

If you have installed Python 3, but `$ python --version` outputs a Python 2 version, you also have Python 2 installed. This is often the case on MacOS, and many Linux distributions. Use `$ python3` instead to explicitly use the Python 3 interpreter.

Hello, World in Python using IDLE

[IDLE](#) is a simple editor for Python, that comes bundled with Python.

How to create Hello, World program in IDLE

- Open IDLE on your system of choice.
 - In older versions of Windows, it can be found at All Programs under the Windows menu.
 - In Windows 8+, search for IDLE or find it in the apps that are present in your system.
 - On Unix-based (including Mac) systems you can open it from the shell by typing `$ idle` `python_file.py`.
- It will open a shell with options along the top.

In the shell, there is a prompt of three right angle brackets:

```
>>>
```

Now write the following code in the prompt:

```
>>> print("Hello, World")
```

Hit .

```
>>> print("Hello, World")
```

```
Hello, World
```

Hello World Python file

Create a new file `hello.py` that contains the following line:

Python 3.x Version \geq 3.0

```
print('Hello, World')
```

Python 2.x Version \geq 2.6

You can use the Python 3 `print` function in Python 2 with the following `import` statement:

```
from __future__ import print_function
```

Python 2 has a number of functionalities that can be optionally imported from Python 3 using the `__future__` module, as discussed here.

Python 2.x Version \leq 2.7

If using Python 2, you may also type the line below. Note that this is not valid in Python 3 and thus not recommended because it reduces cross-version code compatibility.

```
print 'Hello, World'
```

In your terminal, navigate to the directory containing the file `hello.py`.

Type `python hello.py`, then hit the `Enter` key.

```
$ python hello.py
Hello, World
```

You should see `Hello, World` printed to the console.

You can also substitute `hello.py` with the path to your file. For example, if you have the file in your home directory and your user is "user" on Linux, you can type `python /home/user/hello.py`.

Launch an interactive Python shell

By executing (running) the `python` command in your terminal, you are presented with an interactive Python shell. This is also known as the [Python Interpreter](#) or a REPL (for 'Read Evaluate Print Loop').

```
$ python
Python 2.7.12 (default, Jun 28 2016, 08:46:01)
[GCC 6.1.1 20160602] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>> print 'Hello, World'
Hello, World
>>>
```

If you want to run Python 3 from your terminal, execute the command `python3`.

```
$ python3
Python 3.6.0 (default, Jan 13 2017, 00:00:00)
[GCC 6.1.1 20160602] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>> print('Hello, World')
Hello, World
>>>
```

Alternatively, start the interactive prompt and load file with `python -i <file.py>`.

In command line, run:

```
$ python -i hello.py
"Hello World"
>>>
```

There are multiple ways to close the Python shell:

```
>>> exit()
```

or

```
>>> quit()
```

Alternatively, `CTRL + D` will close the shell and put you back on your terminal's command line.

If you want to cancel a command you're in the middle of typing and get back to a clean command prompt, while staying inside the Interpreter shell, use `CTRL + C`.

[Try an interactive Python shell online.](#)

Other Online Shells

Various websites provide online access to Python shells.

Online shells may be useful for the following purposes:

- Run a small code snippet from a machine which lacks python installation (smartphones, tablets etc).
- Learn or teach basic Python.
- Solve online judge problems.

Examples:

Disclaimer: documentation author(s) are not affiliated with any resources listed below.

- <https://www.python.org/shell/> - The online Python shell hosted by the official Python website.
- <https://ideone.com/> - Widely used on the Net to illustrate code snippet behavior.
- <https://repl.it/languages/python3> - Powerful and simple online compiler, IDE and interpreter. Code, compile, and run code in Python.
- https://www.tutorialspoint.com/execute_python_online.php - Full-featured UNIX shell, and a user-friendly project explorer.
- http://rextester.com/l/python3_online_compiler - Simple and easy to use IDE which shows execution time

Run commands as a string

Python can be passed arbitrary code as a string in the shell:

```
$ python -c 'print("Hello, World")'
Hello, World
```

This can be useful when concatenating the results of scripts together in the shell.

Shells and Beyond

Package Management - The PyPA recommended tool for installing Python packages is [PIP](#). To install, on your command line execute `pip install <the package name>`. For instance, `pip install numpy`. (Note: On windows you must add pip to your PATH environment variables. To avoid this, use `python -m pip install <the package name>`)

Shells - So far, we have discussed different ways to run code using Python's native interactive shell. Shells use

Python's interpretive power for experimenting with code real-time. Alternative shells include [IDLE](#) - a pre-bundled GUI, [IPython](#) - known for extending the interactive experience, etc.

Programs - For long-term storage you can save content to .py files and edit/execute them as scripts or programs with external tools e.g. shell, [IDEs](#) (such as [PyCharm](#)), [Jupyter notebooks](#), etc. Intermediate users may use these tools; however, the methods discussed here are sufficient for getting started.

[Python tutor](#) allows you to step through Python code so you can visualize how the program will flow, and helps you to understand where your program went wrong.

[PEP8](#) defines guidelines for formatting Python code. Formatting code well is important so you can quickly read what the code does.

Section 1.2: Creating variables and assigning values

To create a variable in Python, all you need to do is specify the variable name, and then assign a value to it.

```
<variable name> = <value>
```

Python uses = to assign values to variables. There's no need to declare a variable in advance (or to assign a data type to it), assigning a value to a variable itself declares and initializes the variable with that value. There's no way to declare a variable without assigning it an initial value.

```
# Integer
a = 2
print(a)
# Output: 2

# Integer
b = 9223372036854775807
print(b)
# Output: 9223372036854775807

# Floating point
pi = 3.14
print(pi)
# Output: 3.14

# String
c = 'A'
print(c)
# Output: A

# String
name = 'John Doe'
print(name)
# Output: John Doe

# Boolean
q = True
print(q)
# Output: True

# Empty value or null data type
x = None
print(x)
# Output: None
```

Variable assignment works from left to right. So the following will give you an syntax error.

```
0 = x
=> Output: SyntaxError: can't assign to literal
```

You can not use python's keywords as a valid variable name. You can see the list of keyword by:

```
import keyword
print(keyword.kwlist)
```

Rules for variable naming:

1. Variables names must start with a letter or an underscore.

```
x = True    # valid
_y = True   # valid

9x = False  # starts with numeral
=> SyntaxError: invalid syntax

$y = False  # starts with symbol
=> SyntaxError: invalid syntax
```

2. The remainder of your variable name may consist of letters, numbers and underscores.

```
has_0_in_it = "Still Valid"
```

3. Names are case sensitive.

```
x = 9
y = X*5
=> NameError: name 'X' is not defined
```

Even though there's no need to specify a data type when declaring a variable in Python, while allocating the necessary area in memory for the variable, the Python interpreter automatically picks the most suitable built-in type for it:

```
a = 2
print(type(a))
# Output: <type 'int'>

b = 9223372036854775807
print(type(b))
# Output: <type 'int'>

pi = 3.14
print(type(pi))
# Output: <type 'float'>

c = 'A'
print(type(c))
# Output: <type 'str'>

name = 'John Doe'
print(type(name))
# Output: <type 'str'>

q = True
print(type(q))
```



```
# Output: <type 'bool'>

x = None
print(type(x))
# Output: <type 'NoneType'>
```

Now you know the basics of assignment, let's get this subtlety about assignment in python out of the way.

When you use = to do an assignment operation, what's on the left of = is a **name** for the **object** on the right. Finally, what = does is assign the **reference** of the object on the right to the **name** on the left.

That is:

```
a_name = an_object # "a_name" is now a name for the reference to the object "an_object"
```

So, from many assignment examples above, if we pick `pi = 3.14`, then `pi` is a **name** (not **the** name, since an object can have multiple names) for the object `3.14`. If you don't understand something below, come back to this point and read this again! Also, you can take a look at [this](#) for a better understanding.

You can assign multiple values to multiple variables in one line. Note that there must be the same number of arguments on the right and left sides of the = operator:

```
a, b, c = 1, 2, 3
print(a, b, c)
# Output: 1 2 3

a, b, c = 1, 2
=> Traceback (most recent call last):
=> File "name.py", line N, in <module>
=>     a, b, c = 1, 2
=> ValueError: need more than 2 values to unpack

a, b = 1, 2, 3
=> Traceback (most recent call last):
=> File "name.py", line N, in <module>
=>     a, b = 1, 2, 3
=> ValueError: too many values to unpack
```

The error in last example can be obviated by assigning remaining values to equal number of arbitrary variables. This dummy variable can have any name, but it is conventional to use the underscore (_) for assigning unwanted values:

```
a, b, _ = 1, 2, 3
print(a, b)
# Output: 1, 2
```

Note that the number of _ and number of remaining values must be equal. Otherwise 'too many values to unpack error' is thrown as above:

```
a, b, _ = 1, 2, 3, 4
=> Traceback (most recent call last):
=> File "name.py", line N, in <module>
=> a, b, _ = 1, 2, 3, 4
=> ValueError: too many values to unpack (expected 3)
```

You can also assign a single value to several variables simultaneously.

```
a = b = c = 1
print(a, b, c)
# Output: 1 1 1
```

When using such cascading assignment, it is important to note that all three variables `a`, `b` and `c` refer to the *same* object in memory, an `int` object with the value of 1. In other words, `a`, `b` and `c` are three different names given to the same `int` object. Assigning a different object to one of them afterwards doesn't change the others, just as expected:

```
a = b = c = 1    # all three names a, b and c refer to same int object with value 1
print(a, b, c)
# Output: 1 1 1
b = 2            # b now refers to another int object, one with a value of 2
print(a, b, c)
# Output: 1 2 1 # so output is as expected.
```

The above is also true for mutable types (like `list`, `dict`, etc.) just as it is true for immutable types (like `int`, `string`, `tuple`, etc.):

```
x = y = [7, 8, 9] # x and y refer to the same list object just created, [7, 8, 9]
x = [13, 8, 9]    # x now refers to a different list object just created, [13, 8, 9]
print(y)          # y still refers to the list it was first assigned
# Output: [7, 8, 9]
```

So far so good. Things are a bit different when it comes to *modifying* the object (in contrast to *assigning* the name to a different object, which we did above) when the cascading assignment is used for mutable types. Take a look below, and you will see it first hand:

```
x = y = [7, 8, 9] # x and y are two different names for the same list object just created, [7, 8, 9]
x[0] = 13          # we are updating the value of the list [7, 8, 9] through one of its names, x
                   # in this case
print(y)           # printing the value of the list using its other name
# Output: [13, 8, 9] # hence, naturally the change is reflected
```

Nested lists are also valid in python. This means that a list can contain another list as an element.

```
x = [1, 2, [3, 4, 5], 6, 7] # this is nested list
print x[2]
# Output: [3, 4, 5]
print x[2][1]
# Output: 4
```

Lastly, variables in Python do not have to stay the same type as which they were first defined -- you can simply use `=` to assign a new value to a variable, even if that value is of a different type.

```
a = 2
print(a)
# Output: 2

a = "New value"
print(a)
# Output: New value
```

If this bothers you, think about the fact that what's on the left of `=` is just a name for an object. First you call the `int` object with value 2 `a`, then you change your mind and decide to give the name `a` to a `string` object, having value 'New value'. Simple, right?

Section 1.3: Block Indentation

Python uses indentation to define control and loop constructs. This contributes to Python's readability, however, it requires the programmer to pay close attention to the use of whitespace. Thus, editor miscalibration could result in code that behaves in unexpected ways.

Python uses the colon symbol (:) and indentation for showing where blocks of code begin and end (If you come from another language, do not confuse this with somehow being related to the [ternary operator](#)). That is, blocks in Python, such as functions, loops, if clauses and other constructs, have no ending identifiers. All blocks start with a colon and then contain the indented lines below it.

For example:

```
def my_function():    # This is a function definition. Note the colon (:)
    a = 2             # This line belongs to the function because it's indented
    return a          # This line also belongs to the same function
print(my_function())  # This line is OUTSIDE the function block
```

or

```
if a > b:             # If block starts here
    print(a)          # This is part of the if block
else:                 # else must be at the same level as if
    print(b)          # This line is part of the else block
```

Blocks that contain exactly one single-line statement may be put on the same line, though this form is generally not considered good style:

```
if a > b: print(a)
else: print(b)
```

Attempting to do this with more than a single statement will *not* work:

```
if x > y: y = x
    print(y) # IndentationError: unexpected indent

if x > y: while y != z: y -= 1 # SyntaxError: invalid syntax
```

An empty block causes an IndentationError. Use **pass** (a command that does nothing) when you have a block with no content:

```
def will_be_implemented_later():
    pass
```

Spaces vs. Tabs

In short: **always** use 4 spaces for indentation.

Using tabs exclusively is possible but [PEP 8](#), the style guide for Python code, states that spaces are preferred.

Python 3.x Version ≥ 3.0

Python 3 disallows mixing the use of tabs and spaces for indentation. In such case a compile-time error is generated: Inconsistent use of tabs and spaces in indentation and the program will not run.

Python 2.x Version ≤ 2.7

Python 2 allows mixing tabs and spaces in indentation; this is strongly discouraged. The tab character completes the previous indentation to be a [multiple of 8 spaces](#). Since it is common that editors are configured to show tabs as multiple of 4 spaces, this can cause subtle bugs.

Citing [PEP 8](#):

When invoking the Python 2 command line interpreter with the `-t` option, it issues warnings about code that illegally mixes tabs and spaces. When using `-tt` these warnings become errors. These options are highly recommended!

Many editors have "tabs to spaces" configuration. When configuring the editor, one should differentiate between the tab *character* (`'\t'`) and the `Tab` key.

- The tab *character* should be configured to show 8 spaces, to match the language semantics - at least in cases when (accidental) mixed indentation is possible. Editors can also automatically convert the tab character to spaces.
- However, it might be helpful to configure the editor so that pressing the `Tab` key will insert 4 spaces, instead of inserting a tab character.

Python source code written with a mix of tabs and spaces, or with non-standard number of indentation spaces can be made pep8-conformant using [autopep8](#). (A less powerful alternative comes with most Python installations: [reindent.py](#))

Section 1.4: Datatypes

Built-in Types

Booleans

`bool`: A boolean value of either `True` or `False`. Logical operations like `and`, or, `not` can be performed on booleans.

```
x or y    # if x is False then y otherwise x
x and y   # if x is False then x otherwise y
not x     # if x is True then False, otherwise True
```

In Python 2.x and in Python 3.x, a boolean is also an `int`. The `bool` type is a subclass of the `int` type and `True` and `False` are its only instances:

```
issubclass(bool, int) # True
isinstance(True, bool) # True
isinstance(False, bool) # True
```

If boolean values are used in arithmetic operations, their integer values (1 and 0 for `True` and `False`) will be used to return an integer result:

```
True + False == 1 # 1 + 0 == 1
True * True == 1 # 1 * 1 == 1
```

Numbers

- `int`: Integer number

```
a = 2
b = 100
c = 123456789
d = 38563846326424324
```

Integers in Python are of arbitrary sizes.

Note: in older versions of Python, a `long` type was available and this was distinct from `int`. The two have been unified.

- `float`: Floating point number; precision depends on the implementation and system architecture, for CPython the `float` datatype corresponds to a C double.

```
a = 2.0
b = 100.e0
c = 123456789.e1
```

- `complex`: Complex numbers

```
a = 2 + 1j
b = 100 + 10j
```

The `<`, `<=`, `>` and `>=` operators will raise a `TypeError` exception when any operand is a complex number.

Strings

Python 3.x Version \geq 3.0

- `str`: a **unicode string**. The type of `'hello'`
- `bytes`: a **byte string**. The type of `b'hello'`

Python 2.x Version \leq 2.7

- `str`: a **byte string**. The type of `'hello'`
- `bytes`: synonym for `str`
- `unicode`: a **unicode string**. The type of `u'hello'`

Sequences and collections

Python differentiates between ordered sequences and unordered collections (such as `set` and `dict`).

- strings (`str`, `bytes`, `unicode`) are sequences
- `reversed`: A reversed order of `str` with `reversed` function

```
a = reversed('hello')
```

- `tuple`: An ordered collection of `n` values of any type (`n` \geq 0).

```
a = (1, 2, 3)
b = ('a', 1, 'python', (1, 2))
b[2] = 'something else' # returns a TypeError
```

Supports indexing; immutable; hashable if all its members are hashable

- **list**: An ordered collection of n values ($n \geq 0$)

```
a = [1, 2, 3]
b = ['a', 1, 'python', (1, 2), [1, 2]]
b[2] = 'something else' # allowed
```

Not hashable; mutable.

- **set**: An unordered collection of unique values. Items must be [hashable](#).

```
a = {1, 2, 'a'}
```

- **dict**: An unordered collection of unique key-value pairs; keys must be [hashable](#).

```
a = {1: 'one',
      2: 'two'}

b = {'a': [1, 2, 3],
      'b': 'a string'}
```

An object is hashable if it has a hash value which never changes during its lifetime (it needs a `__hash__()` method), and can be compared to other objects (it needs an `__eq__()` method). Hashable objects which compare equality must have the same hash value.

Built-in constants

In conjunction with the built-in datatypes there are a small number of built-in constants in the built-in namespace:

- **True**: The true value of the built-in type `bool`
- **False**: The false value of the built-in type `bool`
- **None**: A singleton object used to signal that a value is absent.
- **Ellipsis** or `...`: used in core Python3+ anywhere and limited usage in Python2.7+ as part of array notation. numpy and related packages use this as a 'include everything' reference in arrays.
- **NotImplemented**: a singleton used to indicate to Python that a special method doesn't support the specific arguments, and Python will try alternatives if available.

```
a = None # No value will be assigned. Any valid datatype can be assigned later
```

Python 3.x Version ≥ 3.0

None doesn't have any natural ordering. Using ordering comparison operators (`<`, `<=`, `>=`, `>`) isn't supported anymore and will raise a `TypeError`.

Python 2.x Version ≤ 2.7

None is always less than any number (`None < -32` evaluates to `True`).

Testing the type of variables

In python, we can check the datatype of an object using the built-in function `type`.

```
a = '123'
print(type(a))
```

```
# Out: <class 'str'>
b = 123
print(type(b))
# Out: <class 'int'>
```

In conditional statements it is possible to test the datatype with `isinstance`. However, it is usually not encouraged to rely on the type of the variable.

```
i = 7
if isinstance(i, int):
    i += 1
elif isinstance(i, str):
    i = int(i)
    i += 1
```

For information on the differences between `type()` and `isinstance()` read: [Differences between isinstance and type in Python](#)

To test if something is of `NoneType`:

```
x = None
if x is None:
    print('Not a surprise, I just defined x as None.')
```

Converting between datatypes

You can perform explicit datatype conversion.

For example, '123' is of `str` type and it can be converted to integer using `int` function.

```
a = '123'
b = int(a)
```

Converting from a float string such as '123.456' can be done using `float` function.

```
a = '123.456'
b = float(a)
c = int(a)      # ValueError: invalid literal for int() with base 10: '123.456'
d = int(b)      # 123
```

You can also convert sequence or collection types

```
a = 'hello'
list(a)  # ['h', 'e', 'l', 'l', 'o']
set(a)   # {'o', 'e', 'l', 'h'}
tuple(a) # ('h', 'e', 'l', 'l', 'o')
```

Explicit string type at definition of literals

With one letter labels just in front of the quotes you can tell what type of string you want to define.

- `b'foo bar'`: results `bytes` in Python 3, `str` in Python 2
- `u'foo bar'`: results `str` in Python 3, `unicode` in Python 2
- `'foo bar'`: results `str`
- `r'foo bar'`: results so called raw string, where escaping special characters is not necessary, everything is taken verbatim as you typed

```
normal = 'foo\nbar'  # foo
```



```
                                # bar
escaped = 'foo\\nbar' # foo\nbar
raw     = r'foo\nbar' # foo\nbar
```

Mutable and Immutable Data Types

An object is called *mutable* if it can be changed. For example, when you pass a list to some function, the list can be changed:

```
def f(m):
    m.append(3) # adds a number to the list. This is a mutation.

x = [1, 2]
f(x)
x == [1, 2] # False now, since an item was added to the list
```

An object is called *immutable* if it cannot be changed in any way. For example, integers are immutable, since there's no way to change them:

```
def bar():
    x = (1, 2)
    g(x)
    x == (1, 2) # Will always be True, since no function can change the object (1, 2)
```

Note that **variables** themselves are mutable, so we can reassign the *variable* `x`, but this does not change the object that `x` had previously pointed to. It only made `x` point to a new object.

Data types whose instances are mutable are called *mutable data types*, and similarly for immutable objects and datatypes.

Examples of immutable Data Types:

- `int`, `long`, `float`, `complex`
- `str`
- `bytes`
- `tuple`
- `frozenset`

Examples of mutable Data Types:

- `bytearray`
- `list`
- `set`
- `dict`

Section 1.5: Collection Types

There are a number of collection types in Python. While types such as `int` and `str` hold a single value, collection types hold multiple values.

Lists

The `list` type is probably the most commonly used collection type in Python. Despite its name, a list is more like an array in other languages, mostly JavaScript. In Python, a list is merely an ordered collection of valid Python values. A list can be created by enclosing values, separated by commas, in square brackets:

```
int_list = [1, 2, 3]
string_list = ['abc', 'defghi']
```

A list can be empty:

```
empty_list = []
```

The elements of a list are not restricted to a single data type, which makes sense given that Python is a dynamic language:

```
mixed_list = [1, 'abc', True, 2.34, None]
```

A list can contain another list as its element:

```
nested_list = [['a', 'b', 'c'], [1, 2, 3]]
```

The elements of a list can be accessed via an *index*, or numeric representation of their position. Lists in Python are *zero-indexed* meaning that the first element in the list is at index 0, the second element is at index 1 and so on:

```
names = ['Alice', 'Bob', 'Craig', 'Diana', 'Eric']
print(names[0]) # Alice
print(names[2]) # Craig
```

Indices can also be negative which means counting from the end of the list (-1 being the index of the last element). So, using the list from the above example:

```
print(names[-1]) # Eric
print(names[-4]) # Bob
```

Lists are mutable, so you can change the values in a list:

```
names[0] = 'Ann'
print(names)
# Outputs ['Ann', 'Bob', 'Craig', 'Diana', 'Eric']
```

Besides, it is possible to add and/or remove elements from a list:

Append object to end of list with `L.append(object)`, returns `None`.

```
names = ['Alice', 'Bob', 'Craig', 'Diana', 'Eric']
names.append("Sia")
print(names)
# Outputs ['Alice', 'Bob', 'Craig', 'Diana', 'Eric', 'Sia']
```

Add a new element to list at a specific index. `L.insert(index, object)`

```
names.insert(1, "Nikki")
print(names)
# Outputs ['Alice', 'Nikki', 'Bob', 'Craig', 'Diana', 'Eric', 'Sia']
```

Remove the first occurrence of a value with `L.remove(value)`, returns `None`

```
names.remove("Bob")
print(names) # Outputs ['Alice', 'Nikki', 'Craig', 'Diana', 'Eric', 'Sia']
```

Get the index in the list of the first item whose value is x. It will show an error if there is no such item.

```
name.index("Alice")
0
```

Count length of list

```
len(names)
6
```

count occurrence of any item in list

```
a = [1, 1, 1, 2, 3, 4]
a.count(1)
3
```

Reverse the list

```
a.reverse()
[4, 3, 2, 1, 1, 1]
# or
a[::-1]
[4, 3, 2, 1, 1, 1]
```

Remove and return item at index (defaults to the last item) with `L.pop([index])`, returns the item

```
names.pop() # Outputs 'Sia'
```

You can iterate over the list elements like below:

```
for element in my_list:
    print (element)
```

Tuples

A **tuple** is similar to a list except that it is fixed-length and immutable. So the values in the tuple cannot be changed nor the values be added to or removed from the tuple. Tuples are commonly used for small collections of values that will not need to change, such as an IP address and port. Tuples are represented with parentheses instead of square brackets:

```
ip_address = ('10.20.30.40', 8080)
```

The same indexing rules for lists also apply to tuples. Tuples can also be nested and the values can be any valid Python valid.

A tuple with only one member must be defined (note the comma) this way:

```
one_member_tuple = ('Only member',)
```

or

```
one_member_tuple = 'Only member', # No brackets
```

or just using **tuple** syntax

```
one_member_tuple = tuple(['Only member'])
```

Dictionaries

A dictionary in Python is a collection of key-value pairs. The dictionary is surrounded by curly braces. Each pair is separated by a comma and the key and value are separated by a colon. Here is an example:

```
state_capitals = {  
    'Arkansas': 'Little Rock',  
    'Colorado': 'Denver',  
    'California': 'Sacramento',  
    'Georgia': 'Atlanta'  
}
```

To get a value, refer to it by its key:

```
ca_capital = state_capitals['California']
```

You can also get all of the keys in a dictionary and then iterate over them:

```
for k in state_capitals.keys():  
    print('{} is the capital of {}'.format(state_capitals[k], k))
```

Dictionaries strongly resemble JSON syntax. The native `json` module in the Python standard library can be used to convert between JSON and dictionaries.

set

A `set` is a collection of elements with no repeats and without insertion order but sorted order. They are used in situations where it is only important that some things are grouped together, and not what order they were included. For large groups of data, it is much faster to check whether or not an element is in a `set` than it is to do the same for a `list`.

Defining a `set` is very similar to defining a dictionary:

```
first_names = {'Adam', 'Beth', 'Charlie'}
```

Or you can build a `set` using an existing `list`:

```
my_list = [1,2,3]  
my_set = set(my_list)
```

Check membership of the `set` using `in`:

```
if name in first_names:  
    print(name)
```

You can iterate over a `set` exactly like a list, but remember: the values will be in an arbitrary, implementation-defined order.

defaultdict

A `defaultdict` is a dictionary with a default value for keys, so that keys for which no value has been explicitly defined can be accessed without errors. `defaultdict` is especially useful when the values in the dictionary are collections (lists, dicts, etc) in the sense that it does not need to be initialized every time when a new key is used.

A defaultdict will never raise a KeyError. Any key that does not exist gets the default value returned.

For example, consider the following dictionary

```
>>> state_capitals = {
    'Arkansas': 'Little Rock',
    'Colorado': 'Denver',
    'California': 'Sacramento',
    'Georgia': 'Atlanta'
}
```

If we try to access a non-existent key, python returns us an error as follows

```
>>> state_capitals['Alabama']
Traceback (most recent call last):

  File "<ipython-input-61-236329695e6f>", line 1, in <module>
    state_capitals['Alabama']

KeyError: 'Alabama'
```

Let us try with a defaultdict. It can be found in the collections module.

```
>>> from collections import defaultdict
>>> state_capitals = defaultdict(lambda: 'Boston')
```

What we did here is to set a default value (**Boston**) in case the give key does not exist. Now populate the dict as before:

```
>>> state_capitals['Arkansas'] = 'Little Rock'
>>> state_capitals['California'] = 'Sacramento'
>>> state_capitals['Colorado'] = 'Denver'
>>> state_capitals['Georgia'] = 'Atlanta'
```

If we try to access the dict with a non-existent key, python will return us the default value i.e. Boston

```
>>> state_capitals['Alabama']
'Boston'
```

and returns the created values for existing key just like a normal dictionary

```
>>> state_capitals['Arkansas']
'Little Rock'
```

Section 1.6: IDLE - Python GUI

IDLE is Python's Integrated Development and Learning Environment and is an alternative to the command line. As the name may imply, IDLE is very useful for developing new code or learning python. On Windows this comes with the Python interpreter, but in other operating systems you may need to install it through your package manager.

The main purposes of IDLE are:

- Multi-window text editor with syntax highlighting, autocompletion, and smart indent
- Python shell with syntax highlighting
- Integrated debugger with stepping, persistent breakpoints, and call stack visibility
- Automatic indentation (useful for beginners learning about Python's indentation)

- Saving the Python program as .py files and run them and edit them later at any them using IDLE.

In IDLE, hit F5 or run Python Shell to launch an interpreter. Using IDLE can be a better learning experience for new users because code is interpreted as the user writes.

Note that there are lots of alternatives, see for example [this discussion](#) or [this list](#).

Troubleshooting

- **Windows**

If you're on Windows, the default command is python. If you receive a "'python' is not recognized" error, the most likely cause is that Python's location is not in your system's PATH environment variable. This can be accessed by right-clicking on 'My Computer' and selecting 'Properties' or by navigating to 'System' through 'Control Panel'. Click on 'Advanced system settings' and then 'Environment Variables...'. Edit the PATH variable to include the directory of your Python installation, as well as the Script folder (usually C:\Python27;C:\Python27\Scripts). This requires administrative privileges and may require a restart.

When using multiple versions of Python on the same machine, a possible solution is to rename one of the python.exe files. For example, naming one version python27.exe would cause python27 to become the Python command for that version.

You can also use the Python Launcher for Windows, which is available through the installer and comes by default. It allows you to select the version of Python to run by using py -[x.y] instead of python[x.y]. You can use the latest version of Python 2 by running scripts with py -2 and the latest version of Python 3 by running scripts with py -3.

- **Debian/Ubuntu/MacOS**

This section assumes that the location of the python executable has been added to the PATH environment variable.

If you're on Debian/Ubuntu/MacOS, open the terminal and type python for Python 2.x or python3 for Python 3.x.

Type which python to see which Python interpreter will be used.

- **Arch Linux**

The default Python on Arch Linux (and descendants) is Python 3, so use python or python3 for Python 3.x and python2 for Python 2.x.

- **Other systems**

Python 3 is sometimes bound to python instead of python3. To use Python 2 on these systems where it is installed, you can use python2.

Section 1.7: User Input

Interactive input

To get input from the user, use the `input` function (**note:** in Python 2.x, the function is called `raw_input` instead, although Python 2.x has its own version of `input` that is completely different):

Python 2.x Version \geq 2.3

```
name = raw_input("What is your name? ")  
# Out: What is your name? _
```

Security Remark Do not use `input()` in Python2 - the entered text will be evaluated as if it were a Python expression (equivalent to `eval(input())` in Python3), which might easily become a vulnerability. See [this article](#) for further information on the risks of using this function.

Python 3.x Version \geq 3.0

```
name = input("What is your name? ")  
# Out: What is your name? _
```

The remainder of this example will be using Python 3 syntax.

The function takes a string argument, which displays it as a prompt and returns a string. The above code provides a prompt, waiting for the user to input.

```
name = input("What is your name? ")  
# Out: What is your name?
```

If the user types "Bob" and hits enter, the variable name will be assigned to the string "Bob":

```
name = input("What is your name? ")  
# Out: What is your name? Bob  
print(name)  
# Out: Bob
```

Note that the `input` is always of type `str`, which is important if you want the user to enter numbers. Therefore, you need to convert the `str` before trying to use it as a number:

```
x = input("Write a number:")  
# Out: Write a number: 10  
x / 2  
# Out: TypeError: unsupported operand type(s) for /: 'str' and 'int'  
float(x) / 2  
# Out: 5.0
```

NB: It's recommended to use `try/except` blocks to catch exceptions when dealing with user inputs. For instance, if your code wants to cast a `raw_input` into an `int`, and what the user writes is uncastable, it raises a `ValueError`.

Section 1.8: Built in Modules and Functions

A module is a file containing Python definitions and statements. Function is a piece of code which execute some logic.

```
>>> pow(2,3)    #8
```


To check the built in function in python we can use `dir()` . If called without an argument, return the names in the current scope. Else, return an alphabetized list of names comprising (some of) the attribute of the given object, and of attributes reachable from it.

```
>>> dir(__builtins__)
[
    'ArithmeticError',
    'AssertionError',
    'AttributeError',
    'BaseException',
    'BufferError',
    'BytesWarning',
    'DeprecationWarning',
    'EOFError',
    'Ellipsis',
    'EnvironmentError',
    'Exception',
    'False',
    'FloatingPointError',
    'FutureWarning',
    'GeneratorExit',
    'IOError',
    'ImportError',
    'ImportWarning',
    'IndentationError',
    'IndexError',
    'KeyError',
    'KeyboardInterrupt',
    'LookupError',
    'MemoryError',
    'NameError',
    'None',
    'NotImplemented',
    'NotImplementedError',
    'OSError',
    'OverflowError',
    'PendingDeprecationWarning',
    'ReferenceError',
    'RuntimeError',
    'RuntimeWarning',
    'StandardError',
    'StopIteration',
    'SyntaxError',
    'SyntaxWarning',
    'SystemError',
    'SystemExit',
    'TabError',
    'True',
    'TypeError',
    'UnboundLocalError',
    'UnicodeDecodeError',
    'UnicodeEncodeError',
    'UnicodeError',
    'UnicodeTranslateError',
    'UnicodeWarning',
    'UserWarning',
    'ValueError',
    'Warning',
    'ZeroDivisionError',
    '__debug__',
    '__doc__',

```

```
'__import__',
'__name__',
'__package__',
'abs',
'all',
'any',
'apply',
'basestring',
'bin',
'bool',
'buffer',
'bytearray',
'bytes',
'callable',
'chr',
'classmethod',
'cmp',
'coerce',
'compile',
'complex',
'copyright',
'credits',
'delattr',
'dict',
'dir',
'divmod',
'enumerate',
'eval',
'execfile',
'exit',
'file',
'filter',
'float',
'format',
'frozenset',
'getattr',
'globals',
'hasattr',
'hash',
'help',
'hex',
'id',
'input',
'int',
'intern',
'isinstance',
'issubclass',
'iter',
'len',
'license',
'list',
'locals',
'long',
'map',
'max',
'memoryview',
'min',
'next',
'object',
'oct',
'open',
'ord',
```

```

'pow',
'print',
'property',
'quit',
'range',
'raw_input',
'reduce',
'reload',
'repr',
'reversed',
'round',
'set',
'setattr',
'slice',
'sorted',
'staticmethod',
'str',
'sum',
'super',
'tuple',
'type',
'unichr',
'unicode',
'vars',
'xrange',
'zip'
]

```

To know the functionality of any function, we can use built in function `help` .

```

>>> help(max)
Help on built-in function max in module __builtin__:
max(...)
    max(iterable[, key=func]) -> value
    max(a, b, c, ...[, key=func]) -> value
    With a single iterable argument, return its largest item.
    With two or more arguments, return the largest argument.

```

Built in modules contains extra functionalities. For example to get square root of a number we need to include `math` module.

```

>>> import math
>>> math.sqrt(16) # 4.0

```

To know all the functions in a module we can assign the functions list to a variable, and then print the variable.

```

>>> import math
>>> dir(math)

['__doc__', '__name__', '__package__', 'acos', 'acosh',
'asin', 'asinh', 'atan', 'atan2', 'atanh', 'ceil', 'copysign',
'cos', 'cosh', 'degrees', 'e', 'erf', 'erfc', 'exp', 'expm1',
'fabs', 'factorial', 'floor', 'fmod', 'frexp', 'fsum', 'gamma',
'hypot', 'isinf', 'isnan', 'ldexp', 'lgamma', 'log', 'log10',
'log1p', 'modf', 'pi', 'pow', 'radians', 'sin', 'sinh', 'sqrt',
'tan', 'tanh', 'trunc']

```

it seems `__doc__` is useful to provide some documentation in, say, functions

```
>>> math.__doc__
'This module is always available. It provides access to the\nmathematical
functions defined by the C standard.'
```

In addition to functions, documentation can also be provided in modules. So, if you have a file named `helloWorld.py` like this:

```
"""This is the module docstring."""

def sayHello():
    """This is the function docstring."""
    return 'Hello World'
```

You can access its docstrings like this:

```
>>> import helloWorld
>>> helloWorld.__doc__
'This is the module docstring.'
>>> helloWorld.sayHello.__doc__
'This is the function docstring.'
```

- For any user defined type, its attributes, its class's attributes, and recursively the attributes of its class's base classes can be retrieved using `dir()`

```
>>> class MyClassObject(object):
...     pass
...
>>> dir(MyClassObject)
['__class__', '__delattr__', '__dict__', '__doc__', '__format__', '__getattribute__', '__hash__',
 '__init__', '__module__', '__new__', '__reduce__', '__reduce_ex__', '__repr__', '__setattr__',
 '__sizeof__', '__str__', '__subclasshook__', '__weakref__']
```

Any data type can be simply converted to string using a builtin function called `str`. This function is called by default when a data type is passed to `print`

```
>>> str(123)    # "123"
```

Section 1.9: Creating a module

A module is an importable file containing definitions and statements.

A module can be created by creating a `.py` file.

```
# hello.py
def say_hello():
    print("Hello!")
```

Functions in a module can be used by importing the module.

For modules that you have made, they will need to be in the same directory as the file that you are importing them into. (However, you can also put them into the Python lib directory with the pre-included modules, but should be avoided if possible.)

```
$ python
>>> import hello
>>> hello.say_hello()
```

```
=> "Hello!"
```

Modules can be imported by other modules.

```
# greet.py
import hello
hello.say_hello()
```

Specific functions of a module can be imported.

```
# greet.py
from hello import say_hello
say_hello()
```

Modules can be aliased.

```
# greet.py
import hello as ai
ai.say_hello()
```

A module can be stand-alone runnable script.

```
# run_hello.py
if __name__ == '__main__':
    from hello import say_hello
    say_hello()
```

Run it!

```
$ python run_hello.py
=> "Hello!"
```

If the module is inside a directory and needs to be detected by python, the directory should contain a file named `__init__.py`.

Section 1.10: Installation of Python 2.7.x and 3.x

Note: Following instructions are written for Python 2.7 (unless specified); instructions for Python 3.x are similar.

Windows

First, download the latest version of Python 2.7 from the official Website (<https://www.python.org/downloads/>). Version is provided as an MSI package. To install it manually, just double-click the file.

By default, Python installs to a directory:

```
C:\Python27\
```

Warning: installation does not automatically modify the PATH environment variable.

Assuming that your Python installation is in C:\Python27, add this to your PATH:

```
C:\Python27\;C:\Python27\Scripts\
```

Now to check if Python installation is valid write in cmd:

```
python --version
```

Python 2.x and 3.x Side-By-Side

To install and use both Python 2.x and 3.x side-by-side on a Windows machine:

1. Install Python 2.x using the MSI installer.
 - Ensure Python is installed for all users.
 - Optional: add Python to PATH to make Python 2.x callable from the command-line using python.
2. Install Python 3.x using its respective installer.
 - Again, ensure Python is installed for all users.
 - Optional: add Python to PATH to make Python 3.x callable from the command-line using python. This may override Python 2.x PATH settings, so double-check your PATH and ensure it's configured to your preferences.
 - Make sure to install the py launcher for all users.

Python 3 will install the Python launcher which can be used to launch Python 2.x and Python 3.x interchangeably from the command-line:

```
P:\>py -3
Python 3.6.1 (v3.6.1:69c0db5, Mar 21 2017, 17:54:52) [MSC v.1900 32 bit (Intel)] on win32
Type "help", "copyright", "credits" or "license" for more information.
>>>

C:\>py -2
Python 2.7.13 (v2.7.13:a06454b1afa1, Dec 17 2016, 20:42:59) [MSC v.1500 32 Intel)] on win32
Type "help", "copyright", "credits" or "license" for more information.
>>>
```

To use the corresponding version of pip for a specific Python version, use:

```
C:\>py -3 -m pip -V
pip 9.0.1 from C:\Python36\lib\site-packages (python 3.6)

C:\>py -2 -m pip -V
pip 9.0.1 from C:\Python27\lib\site-packages (python 2.7)
```

Linux

The latest versions of CentOS, Fedora, Red Hat Enterprise (RHEL) and Ubuntu come with Python 2.7.

To install Python 2.7 on linux manually, just do the following in terminal:

```
wget --no-check-certificate https://www.python.org/ftp/python/2.7.X/Python-2.7.X.tgz
tar -xzf Python-2.7.X.tgz
cd Python-2.7.X
./configure
make
```

```
sudo make install
```

Also add the path of new python in PATH environment variable. If new python is in `/root/python-2.7.X` then run `export PATH = $PATH:/root/python-2.7.X`

Now to check if Python installation is valid write in terminal:

```
python --version
```

Ubuntu (From Source)

If you need Python 3.6 you can install it from source as shown below (Ubuntu 16.10 and 17.04 have 3.6 version in the universal repository). Below steps have to be followed for Ubuntu 16.04 and lower versions:

```
sudo apt install build-essential checkinstall
sudo apt install libreadline-gplv2-dev libncursesw5-dev libssl-dev libsqlite3-dev tk-dev libgdbm-
dev libc6-dev libbz2-dev
wget https://www.python.org/ftp/python/3.6.1/Python-3.6.1.tar.xz
tar xvf Python-3.6.1.tar.xz
cd Python-3.6.1/
./configure --enable-optimizations
sudo make altinstall
```

macOS

As we speak, macOS comes installed with Python 2.7.10, but this version is outdated and slightly modified from the regular Python.

The version of Python that ships with OS X is great for learning but it's not good for development. The version shipped with OS X may be out of date from the official current Python release, which is considered the stable production version. ([source](#))

Install [Homebrew](#):

```
/usr/bin/ruby -e "$(curl -fsSL https://raw.githubusercontent.com/Homebrew/install/master/install)"
```

Install Python 2.7:

```
brew install python
```

For Python 3.x, use the command `brew install python3` instead.

Section 1.11: String function - `str()` and `repr()`

There are two functions that can be used to obtain a readable representation of an object.

`repr(x)` calls `x.__repr__()`: a representation of `x`. `eval` will usually convert the result of this function back to the original object.

`str(x)` calls `x.__str__()`: a human-readable string that describes the object. This may elide some technical detail.

`repr()`

For many types, this function makes an attempt to return a string that would yield an object with the same value when passed to `eval()`. Otherwise, the representation is a string enclosed in angle brackets that contains the name of the type of the object along with additional information. This often includes the name and address of the object.

str()

For strings, this returns the string itself. The difference between this and `repr(object)` is that `str(object)` does not always attempt to return a string that is acceptable to `eval()`. Rather, its goal is to return a printable or 'human readable' string. If no argument is given, this returns the empty string, `''`.

Example 1:

```
s = ""'w'o"w""
repr(s) # Output: '\w\\\'o"w\''
str(s) # Output: 'w\'o"w'
eval(str(s)) == s # Gives a SyntaxError
eval(repr(s)) == s # Output: True
```

Example 2:

```
import datetime
today = datetime.datetime.now()
str(today) # Output: '2016-09-15 06:58:46.915000'
repr(today) # Output: 'datetime.datetime(2016, 9, 15, 6, 58, 46, 915000)'
```

When writing a class, you can override these methods to do whatever you want:

```
class Represent(object):

    def __init__(self, x, y):
        self.x, self.y = x, y

    def __repr__(self):
        return "Represent(x={},y=\"{}\\\"}\".format(self.x, self.y)

    def __str__(self):
        return "Representing x as {} and y as {}".format(self.x, self.y)
```

Using the above class we can see the results:

```
r = Represent(1, "Hopper")
print(r) # prints __str__
print(r.__repr__) # prints __repr__: '<bound method Represent.__repr__ of
Represent(x=1,y="Hopper")>'
rep = r.__repr__() # sets the execution of __repr__ to a new variable
print(rep) # prints 'Represent(x=1,y="Hopper")'
r2 = eval(rep) # evaluates rep
print(r2) # prints __str__ from new object
print(r2 == r) # prints 'False' because they are different objects
```

Section 1.12: Installing external modules using pip

pip is your friend when you need to install any package from the plethora of choices available at the python package index (PyPI). pip is already installed if you're using Python 2 >= 2.7.9 or Python 3 >= 3.4 downloaded from python.org. For computers running Linux or another *nix with a native package manager, pip must often be [manually installed](#).

On instances with both Python 2 and Python 3 installed, `pip` often refers to Python 2 and `pip3` to Python 3. Using `pip` will only install packages for Python 2 and `pip3` will only install packages for Python 3.

Finding / installing a package

Searching for a package is as simple as typing

```
$ pip search <query>
# Searches for packages whose name or summary contains <query>
```

Installing a package is as simple as typing (*in a terminal / command-prompt, not in the Python interpreter*)

```
$ pip install [package_name]          # latest version of the package
$ pip install [package_name]==x.x.x   # specific version of the package
$ pip install '[package_name]>=x.x.x' # minimum version of the package
```

where `x.x.x` is the version number of the package you want to install.

When your server is behind proxy, you can install package by using below command:

```
$ pip --proxy http://<server address>:<port> install
```

Upgrading installed packages

When new versions of installed packages appear they are not automatically installed to your system. To get an overview of which of your installed packages have become outdated, run:

```
$ pip list --outdated
```

To upgrade a specific package use

```
$ pip install [package_name] --upgrade
```

Updating all outdated packages is not a standard functionality of `pip`.

Upgrading pip

You can upgrade your existing `pip` installation by using the following commands

- On Linux or macOS X:

```
$ pip install -U pip
```

You may need to use `sudo` with `pip` on some Linux Systems

- On Windows:

```
py -m pip install -U pip
```

or

```
python -m pip install -U pip
```

For more information regarding pip do [read here](#).

Section 1.13: Help Utility

Python has several functions built into the interpreter. If you want to get information of keywords, built-in functions, modules or topics open a Python console and enter:

```
>>> help()
```

You will receive information by entering keywords directly:

```
>>> help(help)
```

or within the utility:

```
help> help
```

which will show an explanation:

```
Help on _Helper in module _sitebuiltins object:

class _Helper(builtins.object)
| Define the builtin 'help'.
|
| This is a wrapper around pydoc.help that provides a helpful message
| when 'help' is typed at the Python interactive prompt.
|
| Calling help() at the Python prompt starts an interactive help session.
| Calling help(thing) prints help for the python object 'thing'.
|
| Methods defined here:
|
| __call__(self, *args, **kwargs)
|
| __repr__(self)
|
| -----
| Data descriptors defined here:
|
| __dict__
| dictionary for instance variables (if defined)
|
| __weakref__
| list of weak references to the object (if defined)
```

You can also request subclasses of modules:

```
help(pymysql.connections)
```

You can use help to access the docstrings of the different modules you have imported, e.g., try the following:

```
>>> help(math)
```

and you'll get an error

```
>>> import math
```

```
>>> help(math)
```

And now you will get a list of the available methods in the module, but only AFTER you have imported it.

Close the helper with quit

Chapter 2: Python Data Types

Data types are nothing but variables you use to reserve some space in memory. Python variables do not need an explicit declaration to reserve memory space. The declaration happens automatically when you assign a value to a variable.

Section 2.1: String Data Type

String are identified as a contiguous set of characters represented in the quotation marks. Python allows for either pairs of single or double quotes. Strings are immutable sequence data type, i.e each time one makes any changes to a string, completely new string object is created.

```
a_str = 'Hello World'
print(a_str)      #output will be whole string. Hello World
print(a_str[0])   #output will be first character. H
print(a_str[0:5]) #output will be first five characters. Hello
```

Section 2.2: Set Data Types

Sets are unordered collections of unique objects, there are two types of set:

1. Sets - They are mutable and new elements can be added once sets are defined

```
basket = {'apple', 'orange', 'apple', 'pear', 'orange', 'banana'}
print(basket)           # duplicates will be removed
> {'orange', 'banana', 'pear', 'apple'}
a = set('abracadabra')
print(a)                # unique letters in a
> {'a', 'r', 'b', 'c', 'd'}
a.add('z')
print(a)
> {'a', 'c', 'r', 'b', 'z', 'd'}
```

2. Frozen Sets - They are immutable and new elements cannot added after its defined.

```
b = frozenset('asdfagsa')
print(b)
> frozenset({'f', 'g', 'd', 'a', 's'})
cities = frozenset(["Frankfurt", "Basel","Freiburg"])
print(cities)
> frozenset({'Frankfurt', 'Basel', 'Freiburg'})
```

Section 2.3: Numbers data type

Numbers have four types in Python. Int, float, complex, and long.

```
int_num = 10      #int value
float_num = 10.2   #float value
complex_num = 3.14j #complex value
long_num = 1234567L #long value
```

Section 2.4: List Data Type

A list contains items separated by commas and enclosed within square brackets []. Lists are almost similar to arrays in C. One difference is that all the items belonging to a list can be of different data type.

```
list = [123, 'abcd', 10.2, 'd']    #can be an array of any data type or single data type.
list1 = ['hello', 'world']
print(list)    #will output whole list. [123, 'abcd', 10.2, 'd']
print(list[0:2])    #will output first two element of list. [123, 'abcd']
print(list1 * 2)    #will gave list1 two times. ['hello', 'world', 'hello', 'world']
print(list + list1)    #will gave concatenation of both the lists.
[123, 'abcd', 10.2, 'd', 'hello', 'world']
```

Section 2.5: Dictionary Data Type

Dictionary consists of key-value pairs. It is enclosed by curly braces {} and values can be assigned and accessed using square brackets [].

```
dic={'name':'red', 'age':10}
print(dic)    #will output all the key-value pairs. {'name':'red', 'age':10}
print(dic['name'])    #will output only value with 'name' key. 'red'
print(dic.values())    #will output list of values in dic. ['red', 10]
print(dic.keys())    #will output list of keys. ['name', 'age']
```

Section 2.6: Tuple Data Type

Lists are enclosed in brackets [] and their elements and size can be changed, while tuples are enclosed in parentheses () and cannot be updated. Tuples are immutable.

```
tuple = (123, 'hello')
tuple1 = ('world')
print(tuple)    #will output whole tuple. (123, 'hello')
print(tuple[0])    #will output first value. (123)
print(tuple + tuple1)    #will output (123, 'hello', 'world')
tuple[1]='update'    #this will give you error.
```

Chapter 3: Indentation

Section 3.1: Simple example

For Python, Guido van Rossum based the grouping of statements on indentation. The reasons for this are explained in [the first section of the "Design and History Python FAQ"](#). Colons, :, are used to [declare an indented code block](#), such as the following example:

```
class ExampleClass:
    #Every function belonging to a class must be indented equally
    def __init__(self):
        name = "example"

    def someFunction(self, a):
        #Notice everything belonging to a function must be indented
        if a > 5:
            return True
        else:
            return False

#If a function is not indented to the same level it will not be considers as part of the parent class
def separateFunction(b):
    for i in b:
        #Loops are also indented and nested conditions start a new indentation
        if i == 1:
            return True
    return False

separateFunction([2,3,5,6,1])
```

Spaces or Tabs?

The recommended [indentation is 4 spaces](#) but tabs or spaces can be used so long as they are consistent. **Do not mix tabs and spaces in Python** as this will cause an error in Python 3 and can causes errors in [Python 2](#).

Section 3.2: How Indentation is Parsed

Whitespace is handled by the lexical analyzer before being parsed.

The lexical analyzer uses a stack to store indentation levels. At the beginning, the stack contains just the value 0, which is the leftmost position. Whenever a nested block begins, the new indentation level is pushed on the stack, and an "INDENT" token is inserted into the token stream which is passed to the parser. There can never be more than one "INDENT" token in a row (IndentationError).

When a line is encountered with a smaller indentation level, values are popped from the stack until a value is on top which is equal to the new indentation level (if none is found, a syntax error occurs). For each value popped, a "DEDENT" token is generated. Obviously, there can be multiple "DEDENT" tokens in a row.

The lexical analyzer skips empty lines (those containing only whitespace and possibly comments), and will never generate either "INDENT" or "DEDENT" tokens for them.

At the end of the source code, "DEDENT" tokens are generated for each indentation level left on the stack, until just the 0 is left.

For example:


```

if foo:
    if bar:
        x = 42
else:
    print foo

```

is analyzed as:

<if> <foo> <:>	[0]
<INDENT> <if> <bar> <:>	[0, 4]
<INDENT> <x> <=> <42>	[0, 4, 8]
<DEDENT> <DEDENT> <else> <:>	[0]
<INDENT> <print> <foo>	[0, 2]
<DEDENT>	

The parser then handles the "INDENT" and "DEDENT" tokens as block delimiters.

Section 3.3: Indentation Errors

The spacing should be even and uniform throughout. Improper indentation can cause an `IndentationError` or cause the program to do something unexpected. The following example raises an `IndentationError`:

```

a = 7
if a > 5:
    print "foo"
else:
    print "bar"
print "done"

```

Or if the line following a colon is not indented, an `IndentationError` will also be raised:

```

if True:
print "true"

```

If you add indentation where it doesn't belong, an `IndentationError` will be raised:

```

if True:
    a = 6
    b = 5

```

If you forget to un-indent functionality could be lost. In this example `None` is returned instead of the expected `False`:

```

def isEven(a):
    if a%2 ==0:
        return True
        #this next line should be even with the if
        return False
print isEven(7)

```

Chapter 4: Comments and Documentation

Section 4.1: Single line, inline and multiline comments

Comments are used to explain code when the basic code itself isn't clear.

Python ignores comments, and so will not execute code in there, or raise syntax errors for plain English sentences.

Single-line comments begin with the hash character (#) and are terminated by the end of line.

- Single line comment:

```
# This is a single line comment in Python
```

- Inline comment:

```
print("Hello World") # This line prints "Hello World"
```

- Comments spanning multiple lines have `"""` or `'''` on either end. This is the same as a multiline string, but they can be used as comments:

```
"""
This type of comment spans multiple lines.
These are mostly used for documentation of functions, classes and modules.
"""
```

Section 4.2: Programmatically accessing docstrings

Docstrings are - unlike regular comments - stored as an attribute of the function they document, meaning that you can access them programmatically.

An example function

```
def func():
    """This is a function that does nothing at all"""
    return
```

The docstring can be accessed using the `__doc__` attribute:

```
print(func.__doc__)
```

```
This is a function that does nothing at all
```

```
help(func)
```

```
Help on function func in module __main__:
```

```
func()
```

```
This is a function that does nothing at all
```

Another example function

`function.__doc__` is just the actual docstring as a string, while the `help` function provides general information about a function, including the docstring. Here's a more helpful example:

```
def greet(name, greeting="Hello"):
    """Print a greeting to the user `name`

    Optional parameter `greeting` can change what they're greeted with."""

    print("{} {}".format(greeting, name))

help(greet)
```

```
Help on function greet in module __main__:
greet(name, greeting='Hello')

    Print a greeting to the user name
    Optional parameter greeting can change what they're greeted with.
```

Advantages of docstrings over regular comments

Just putting no docstring or a regular comment in a function makes it a lot less helpful.

```
def greet(name, greeting="Hello"):
    # Print a greeting to the user `name`
    # Optional parameter `greeting` can change what they're greeted with.

    print("{} {}".format(greeting, name))

print(greet.__doc__)
```

```
None
```

```
help(greet)
```

```
Help on function greet in module main:
greet(name, greeting='Hello')
```

Section 4.3: Write documentation using docstrings

A [docstring](#) is a multi-line comment used to document modules, classes, functions and methods. It has to be the first statement of the component it describes.

```
def hello(name):
    """Greet someone.

    Print a greeting ("Hello") for the person with the given name.
    """

    print("Hello " + name)

class Greeter:
    """An object used to greet people.
```

```
It contains multiple greeting functions for several languages
and times of the day.
"""
```

The value of the docstring can be accessed within the program and is - for example - used by the `help` command.

Syntax conventions

PEP 257

[PEP 257](#) defines a syntax standard for docstring comments. It basically allows two types:

- One-line Docstrings:

According to PEP 257, they should be used with short and simple functions. Everything is placed in one line, e.g:

```
def hello():
    """Say hello to your friends."""
    print("Hello my friends!")
```

The docstring shall end with a period, the verb should be in the imperative form.

- Multi-line Docstrings:

Multi-line docstring should be used for longer, more complex functions, modules or classes.

```
def hello(name, language="en"):
    """Say hello to a person.

    Arguments:
    name: the name of the person
    language: the language in which the person should be greeted
    """

    print(greeting[language]+" "+name)
```

They start with a short summary (equivalent to the content of a one-line docstring) which can be on the same line as the quotation marks or on the next line, give additional detail and list parameters and return values.

Note PEP 257 defines [what information should be given](#) within a docstring, it doesn't define in which format it should be given. This was the reason for other parties and documentation parsing tools to specify their own standards for documentation, some of which are listed below and in [this question](#).

Sphinx

[Sphinx](#) is a tool to generate HTML based documentation for Python projects based on docstrings. Its markup language used is [reStructuredText](#). They define their own standards for documentation, pythonhosted.org hosts a [very good description of them](#). The Sphinx format is for example used by the [pyCharm IDE](#).

A function would be documented like this using the Sphinx/reStructuredText format:

```
def hello(name, language="en"):
    """Say hello to a person.

    :param name: the name of the person
    :type name: str
    :param language: the language in which the person should be greeted
    :type language: str
```

```

:~return: a number
:~rtype: int
"""

print(greeting[language]+" "+name)
return 4

```

Google Python Style Guide

Google has published [Google Python Style Guide](#) which defines coding conventions for Python, including documentation comments. In comparison to the Sphinx/reST many people say that documentation according to Google's guidelines is better human-readable.

The [pythonhosted.org page mentioned above](#) also provides some examples for good documentation according to the Google Style Guide.

Using the [Napoleon](#) plugin, Sphinx can also parse documentation in the Google Style Guide-compliant format.

A function would be documented like this using the Google Style Guide format:

```

def hello(name, language="en"):
    """Say hello to a person.

    Args:
        name: the name of the person as string
        language: the language code string

    Returns:
        A number.
    """

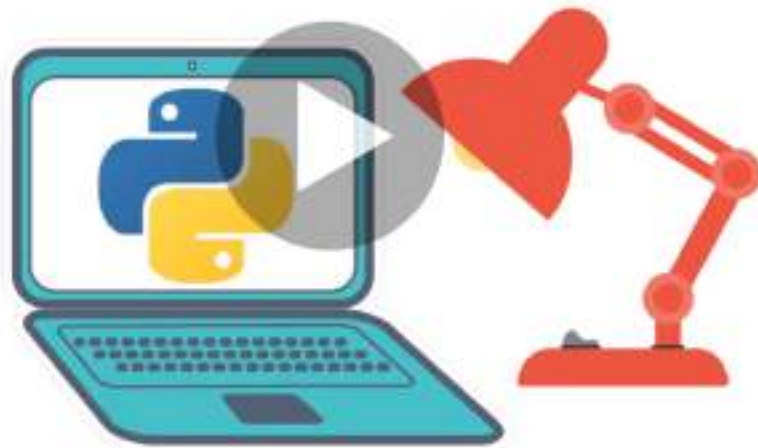
    print(greeting[language]+" "+name)
    return 4

```

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Chapter 5: Date and Time

Section 5.1: Parsing a string into a timezone aware datetime object

Python 3.2+ has support for %z format when [parsing a string](#) into a `datetime` object.

UTC offset in the form +HHMM or -HHMM (empty string if the object is naive).

Python 3.x Version \geq 3.2

```
import datetime
dt = datetime.datetime.strptime("2016-04-15T08:27:18-0500", "%Y-%m-%dT%H:%M:%S%z")
```

For other versions of Python, you can use an external library such as [dateutil](#), which makes parsing a string with timezone into a `datetime` object is quick.

```
import dateutil.parser
dt = dateutil.parser.parse("2016-04-15T08:27:18-0500")
```

The dt variable is now a `datetime` object with the following value:

```
datetime.datetime(2016, 4, 15, 8, 27, 18, tzinfo=tzoffset(None, -18000))
```

Section 5.2: Constructing timezone-aware datetimes

By default all `datetime` objects are naive. To make them timezone-aware, you must attach a `tzinfo` object, which provides the UTC offset and timezone abbreviation as a function of date and time.

Fixed Offset Time Zones

For time zones that are a fixed offset from UTC, in Python 3.2+, the `datetime` module provides the `timezone` class, a concrete implementation of `tzinfo`, which takes a `timedelta` and an (optional) name parameter:

Python 3.x Version \geq 3.2

```
from datetime import datetime, timedelta, timezone
JST = timezone(timedelta(hours=+9))

dt = datetime(2015, 1, 1, 12, 0, 0, tzinfo=JST)
print(dt)
# 2015-01-01 12:00:00+09:00

print(dt.tzname())
# UTC+09:00

dt = datetime(2015, 1, 1, 12, 0, 0, tzinfo=timezone(timedelta(hours=9), 'JST'))
print(dt.tzname())
# 'JST'
```

For Python versions before 3.2, it is necessary to use a third party library, such as [dateutil](#). `dateutil` provides an equivalent class, `tzoffset`, which (as of version 2.5.3) takes arguments of the form `dateutil.tz.tzoffset(tzname, offset)`, where `offset` is specified in seconds:

Python 3.x Version $<$ 3.2

Python 2.x Version < 2.7

```
from datetime import datetime, timedelta
from dateutil import tz

JST = tz.tzoffset('JST', 9 * 3600) # 3600 seconds per hour
dt = datetime(2015, 1, 1, 12, 0, tzinfo=JST)
print(dt)
# 2015-01-01 12:00:00+09:00
print(dt.tzname)
# 'JST'
```

Zones with daylight savings time

For zones with daylight savings time, python standard libraries do not provide a standard class, so it is necessary to use a third party library. [pytz](#) and `dateutil` are popular libraries providing time zone classes.

In addition to static time zones, `dateutil` provides time zone classes that use daylight savings time (see [the documentation for the tz module](#)). You can use the `tz.gettz()` method to get a time zone object, which can then be passed directly to the `datetime` constructor:

```
from datetime import datetime
from dateutil import tz
local = tz.gettz() # Local time
PT = tz.gettz('US/Pacific') # Pacific time

dt_l = datetime(2015, 1, 1, 12, tzinfo=local) # I am in EST
dt_pst = datetime(2015, 1, 1, 12, tzinfo=PT)
dt_pdt = datetime(2015, 7, 1, 12, tzinfo=PT) # DST is handled automatically
print(dt_l)
# 2015-01-01 12:00:00-05:00
print(dt_pst)
# 2015-01-01 12:00:00-08:00
print(dt_pdt)
# 2015-07-01 12:00:00-07:00
```

CAUTION: As of version 2.5.3, `dateutil` does not handle ambiguous datetimes correctly, and will always default to the *later* date. There is no way to construct an object with a `dateutil` timezone representing, for example `2015-11-01 1:30 EDT-4`, since this is *during* a daylight savings time transition.

All edge cases are handled properly when using `pytz`, but `pytz` time zones should *not* be directly attached to time zones through the constructor. Instead, a `pytz` time zone should be attached using the time zone's `localize` method:

```
from datetime import datetime, timedelta
import pytz

PT = pytz.timezone('US/Pacific')
dt_pst = PT.localize(datetime(2015, 1, 1, 12))
dt_pdt = PT.localize(datetime(2015, 11, 1, 0, 30))
print(dt_pst)
# 2015-01-01 12:00:00-08:00
print(dt_pdt)
# 2015-11-01 00:30:00-07:00
```

Be aware that if you perform `datetime` arithmetic on a `pytz`-aware time zone, you must either perform the calculations in UTC (if you want absolute elapsed time), or you must call `normalize()` on the result:


```
dt_new = dt_pdt + timedelta(hours=3) # This should be 2:30 AM PST
print(dt_new)
# 2015-11-01 03:30:00-07:00
dt_corrected = PT.normalize(dt_new)
print(dt_corrected)
# 2015-11-01 02:30:00-08:00
```

Section 5.3: Computing time differences

the `timedelta` module comes in handy to compute differences between times:

```
from datetime import datetime, timedelta
now = datetime.now()
then = datetime(2016, 5, 23) # datetime.datetime(2016, 05, 23, 0, 0, 0)
```

Specifying time is optional when creating a new `datetime` object

```
delta = now - then
```

`delta` is of type `timedelta`

```
print(delta.days)
# 60
print(delta.seconds)
# 40826
```

To get `n` day's after and `n` day's before date we could use:

`n` day's after date:

```
def get_n_days_after_date(date_format="%d %B %Y", add_days=120):
    date_n_days_after = datetime.datetime.now() + timedelta(days=add_days)
    return date_n_days_after.strftime(date_format)
```

`n` day's before date:

```
def get_n_days_before_date(self, date_format="%d %B %Y", days_before=120):
    date_n_days_ago = datetime.datetime.now() - timedelta(days=days_before)
    return date_n_days_ago.strftime(date_format)
```

Section 5.4: Basic datetime objects usage

The `datetime` module contains three primary types of objects - date, time, and datetime.

```
import datetime

# Date object
today = datetime.date.today()
new_year = datetime.date(2017, 01, 01) #datetime.date(2017, 1, 1)

# Time object
noon = datetime.time(12, 0, 0) #datetime.time(12, 0)

# Current datetime
now = datetime.datetime.now()
```

```
# Datetime object
millenium_turn = datetime.datetime(2000, 1, 1, 0, 0, 0) #datetime.datetime(2000, 1, 1, 0, 0)
```

Arithmetic operations for these objects are only supported within same datatype and performing simple arithmetic with instances of different types will result in a `TypeError`.

```
# subtraction of noon from today
noon-today
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: unsupported operand type(s) for -: 'datetime.time' and 'datetime.date'
However, it is straightforward to convert between types.

# Do this instead
print('Time since the millenium at midnight: ',
      datetime.datetime(today.year, today.month, today.day) - millenium_turn)

# Or this
print('Time since the millenium at noon: ',
      datetime.datetime.combine(today, noon) - millenium_turn)
```

Section 5.5: Switching between time zones

To switch between time zones, you need datetime objects that are timezone-aware.

```
from datetime import datetime
from dateutil import tz

utc = tz.tzutc()
local = tz.tzlocal()

utc_now = datetime.utcnow()
utc_now # Not timezone-aware.

utc_now = utc_now.replace(tzinfo=utc)
utc_now # Timezone-aware.

local_now = utc_now.astimezone(local)
local_now # Converted to local time.
```

Section 5.6: Simple date arithmetic

Dates don't exist in isolation. It is common that you will need to find the amount of time between dates or determine what the date will be tomorrow. This can be accomplished using [timedelta](#) objects

```
import datetime

today = datetime.date.today()
print('Today:', today)

yesterday = today - datetime.timedelta(days=1)
print('Yesterday:', yesterday)

tomorrow = today + datetime.timedelta(days=1)
print('Tomorrow:', tomorrow)

print('Time between tomorrow and yesterday:', tomorrow - yesterday)
```

This will produce results similar to:

```
Today: 2016-04-15
Yesterday: 2016-04-14
Tomorrow: 2016-04-16
Difference between tomorrow and yesterday: 2 days, 0:00:00
```

Section 5.7: Converting timestamp to datetime

The `datetime` module can convert a POSIX timestamp to a ITC `datetime` object.

The Epoch is January 1st, 1970 midnight.

```
import time
from datetime import datetime
seconds_since_epoch=time.time() #1469182681.709

utc_date=datetime.utcfromtimestamp(seconds_since_epoch) #datetime.datetime(2016, 7, 22, 10, 18, 1, 709000)
```

Section 5.8: Subtracting months from a date accurately

Using the `calendar` module

```
import calendar
from datetime import date

def monthdelta(date, delta):
    m, y = (date.month+delta) % 12, date.year + ((date.month)+delta-1) // 12
    if not m: m = 12
    d = min(date.day, calendar.monthrange(y, m)[1])
    return date.replace(day=d, month=m, year=y)

next_month = monthdelta(date.today(), 1) #datetime.date(2016, 10, 23)
```

Using the `dateutil` module

```
import datetime
import dateutil.relativedelta

d = datetime.datetime.strptime("2013-03-31", "%Y-%m-%d")
d2 = d - dateutil.relativedelta.relativedelta(months=1) #datetime.datetime(2013, 2, 28, 0, 0)
```

Section 5.9: Parsing an arbitrary ISO 8601 timestamp with minimal libraries

Python has only limited support for parsing ISO 8601 timestamps. For `strptime` you need to know exactly what format it is in. As a complication the stringification of a `datetime` is an ISO 8601 timestamp, with space as a separator and 6 digit fraction:

```
str(datetime.datetime(2016, 7, 22, 9, 25, 59, 555555))
# '2016-07-22 09:25:59.555555'
```

but if the fraction is 0, no fractional part is output

```
str(datetime.datetime(2016, 7, 22, 9, 25, 59, 0))
# '2016-07-22 09:25:59'
```

But these 2 forms need a *different* format for `strptime`. Furthermore, `strptime` does not support at all parsing minute timezones that have a `:` in it, thus `2016-07-22 09:25:59+03:00` can be parsed, but the standard format `2016-07-22 09:25:59+03:00` cannot.

There is a [single-file](#) library called [iso8601](#) which properly parses ISO 8601 timestamps and only them.

It supports fractions and timezones, and the T separator all with a single function:

```
import iso8601
iso8601.parse_date('2016-07-22 09:25:59')
# datetime.datetime(2016, 7, 22, 9, 25, 59, tzinfo=<iso8601.Utc>)
iso8601.parse_date('2016-07-22 09:25:59+03:00')
# datetime.datetime(2016, 7, 22, 9, 25, 59, tzinfo=<FixedOffset '+03:00' ...>)
iso8601.parse_date('2016-07-22 09:25:59Z')
# datetime.datetime(2016, 7, 22, 9, 25, 59, tzinfo=<iso8601.Utc>)
iso8601.parse_date('2016-07-22T09:25:59.000111+03:00')
# datetime.datetime(2016, 7, 22, 9, 25, 59, 111, tzinfo=<FixedOffset '+03:00' ...>)
```

If no timezone is set, `iso8601.parse_date` defaults to UTC. The default zone can be changed with `default_timezone` keyword argument. Notably, if this is `None` instead of the default, then those timestamps that do not have an explicit timezone are returned as naive datetimes instead:

```
iso8601.parse_date('2016-07-22T09:25:59', default_timezone=None)
# datetime.datetime(2016, 7, 22, 9, 25, 59)
iso8601.parse_date('2016-07-22T09:25:59Z', default_timezone=None)
# datetime.datetime(2016, 7, 22, 9, 25, 59, tzinfo=<iso8601.Utc>)
```

Section 5.10: Get an ISO 8601 timestamp

Without timezone, with microseconds

```
from datetime import datetime

datetime.now().isoformat()
# Out: '2016-07-31T23:08:20.886783'
```

With timezone, with microseconds

```
from datetime import datetime
from dateutil.tz import tzlocal

datetime.now(tzlocal()).isoformat()
# Out: '2016-07-31T23:09:43.535074-07:00'
```

With timezone, without microseconds

```
from datetime import datetime
from dateutil.tz import tzlocal

datetime.now(tzlocal()).replace(microsecond=0).isoformat()
# Out: '2016-07-31T23:10:30-07:00'
```

See [ISO 8601](#) for more information about the ISO 8601 format.

Section 5.11: Parsing a string with a short time zone name into

a timezone aware datetime object

Using the [dateutil](#) library as in the previous example on parsing timezone-aware timestamps, it is also possible to parse timestamps with a specified "short" time zone name.

For dates formatted with short time zone names or abbreviations, which are generally ambiguous (e.g. CST, which could be Central Standard Time, China Standard Time, Cuba Standard Time, etc - more can be found [here](#)) or not necessarily available in a standard database, it is necessary to specify a mapping between time zone abbreviation and tzinfo object.

```
from dateutil import tz
from dateutil.parser import parse

ET = tz.gettz('US/Eastern')
CT = tz.gettz('US/Central')
MT = tz.gettz('US/Mountain')
PT = tz.gettz('US/Pacific')

us_tzinfos = {'CST': CT, 'CDT': CT,
              'EST': ET, 'EDT': ET,
              'MST': MT, 'MDT': MT,
              'PST': PT, 'PDT': PT}

dt_est = parse('2014-01-02 04:00:00 EST', tzinfos=us_tzinfos)
dt_pst = parse('2016-03-11 16:00:00 PST', tzinfos=us_tzinfos)
```

After running this:

```
dt_est
# datetime.datetime(2014, 1, 2, 4, 0, tzinfo=tzfile('/usr/share/zoneinfo/US/Eastern'))
dt_pst
# datetime.datetime(2016, 3, 11, 16, 0, tzinfo=tzfile('/usr/share/zoneinfo/US/Pacific'))
```

It is worth noting that if using a pytz time zone with this method, it will *not* be properly localized:

```
from dateutil.parser import parse
import pytz

EST = pytz.timezone('America/New_York')
dt = parse('2014-02-03 09:17:00 EST', tzinfos={'EST': EST})
```

This simply attaches the pytz time zone to the datetime:

```
dt.tzinfo # Will be in Local Mean Time!
# <DstTzInfo 'America/New_York' LMT-1 day, 19:04:00 STD>
```

If using this method, you should probably re-localize the naive portion of the datetime after parsing:

```
dt_fixed = dt.tzinfo.localize(dt.replace(tzinfo=None))
dt_fixed.tzinfo # Now it's EST.
# <DstTzInfo 'America/New_York' EST-1 day, 19:00:00 STD>
```

Section 5.12: Fuzzy datetime parsing (extracting datetime out of a text)

It is possible to extract a date out of a text using the [dateutil parser](#) in a "fuzzy" mode, where components of the

string not recognized as being part of a date are ignored.

```
from dateutil.parser import parse

dt = parse("Today is January 1, 2047 at 8:21:00AM", fuzzy=True)
print(dt)
```

dt is now a *datetime* object and you would see `datetime.datetime(2047, 1, 1, 8, 21)` printed.

Section 5.13: Iterate over dates

Sometimes you want to iterate over a range of dates from a start date to some end date. You can do it using *datetime* library and *timedelta* object:

```
import datetime

# The size of each step in days
day_delta = datetime.timedelta(days=1)

start_date = datetime.date.today()
end_date = start_date + 7*day_delta

for i in range((end_date - start_date).days):
    print(start_date + i*day_delta)
```

Which produces:

```
2016-07-21
2016-07-22
2016-07-23
2016-07-24
2016-07-25
2016-07-26
2016-07-27
```

Chapter 6: Date Formatting

Section 6.1: Time between two date-times

```
from datetime import datetime

a = datetime(2016, 10, 06, 0, 0, 0)
b = datetime(2016, 10, 01, 23, 59, 59)

a-b
# datetime.timedelta(4, 1)

(a-b).days
# 4
(a-b).total_seconds()
# 518399.0
```

Section 6.2: Outputting datetime object to string

Uses C standard [format codes](#).

```
from datetime import datetime
datetime_for_string = datetime(2016, 10, 1, 0, 0)
datetime_string_format = '%b %d %Y, %H:%M:%S'
datetime.strftime(datetime_for_string, datetime_string_format)
# Oct 01 2016, 00:00:00
```

Section 6.3: Parsing string to datetime object

Uses C standard [format codes](#).

```
from datetime import datetime
datetime_string = 'Oct 1 2016, 00:00:00'
datetime_string_format = '%b %d %Y, %H:%M:%S'
datetime.strptime(datetime_string, datetime_string_format)
# datetime.datetime(2016, 10, 1, 0, 0)
```

Chapter 7: Enum

Section 7.1: Creating an enum (Python 2.4 through 3.3)

Enums have been backported from Python 3.4 to Python 2.4 through Python 3.3. You can get this the [enum34](#) backport from PyPI.

```
pip install enum34
```

Creation of an enum is identical to how it works in Python 3.4+

```
from enum import Enum

class Color(Enum):
    red = 1
    green = 2
    blue = 3

print(Color.red) # Color.red
print(Color(1)) # Color.red
print(Color['red']) # Color.red
```

Section 7.2: Iteration

Enums are iterable:

```
class Color(Enum):
    red = 1
    green = 2
    blue = 3

[c for c in Color] # [<Color.red: 1>, <Color.green: 2>, <Color.blue: 3>]
```


Chapter 8: Set

Section 8.1: Operations on sets

with other sets

```
# Intersection
{1, 2, 3, 4, 5}.intersection({3, 4, 5, 6}) # {3, 4, 5}
{1, 2, 3, 4, 5} & {3, 4, 5, 6}             # {3, 4, 5}

# Union
{1, 2, 3, 4, 5}.union({3, 4, 5, 6}) # {1, 2, 3, 4, 5, 6}
{1, 2, 3, 4, 5} | {3, 4, 5, 6}      # {1, 2, 3, 4, 5, 6}

# Difference
{1, 2, 3, 4}.difference({2, 3, 5}) # {1, 4}
{1, 2, 3, 4} - {2, 3, 5}           # {1, 4}

# Symmetric difference with
{1, 2, 3, 4}.symmetric_difference({2, 3, 5}) # {1, 4, 5}
{1, 2, 3, 4} ^ {2, 3, 5}                   # {1, 4, 5}

# Superset check
{1, 2}.issuperset({1, 2, 3}) # False
{1, 2} >= {1, 2, 3}          # False

# Subset check
{1, 2}.issubset({1, 2, 3}) # True
{1, 2} <= {1, 2, 3}        # True

# Disjoint check
{1, 2}.isdisjoint({3, 4}) # True
{1, 2}.isdisjoint({1, 4}) # False
```

with single elements

```
# Existence check
2 in {1,2,3} # True
4 in {1,2,3} # False
4 not in {1,2,3} # True

# Add and Remove
s = {1,2,3}
s.add(4) # s == {1,2,3,4}

s.discard(3) # s == {1,2,4}
s.discard(5) # s == {1,2,4}

s.remove(2) # s == {1,4}
s.remove(2) # KeyError!
```

Set operations return new sets, but have the corresponding in-place versions:

method	in-place operation	in-place method
union	<code>s = t</code>	<code>update</code>
intersection	<code>s &= t</code>	<code>intersection_update</code>
difference	<code>s -= t</code>	<code>difference_update</code>

symmetric_difference s ^= t

symmetric_difference_update

For example:

```
s = {1, 2}
s.update({3, 4})    # s == {1, 2, 3, 4}
```

Section 8.2: Get the unique elements of a list

Let's say you've got a list of restaurants -- maybe you read it from a file. You care about the *unique* restaurants in the list. The best way to get the unique elements from a list is to turn it into a set:

```
restaurants = ["McDonald's", "Burger King", "McDonald's", "Chicken Chicken"]
unique_restaurants = set(restaurants)
print(unique_restaurants)
# prints {'Chicken Chicken', 'McDonald's', 'Burger King'}
```

Note that the set is not in the same order as the original list; that is because sets are *unordered*, just like *dicts*.

This can easily be transformed back into a List with Python's built in *list* function, giving another list that is the same list as the original but without duplicates:

```
list(unique_restaurants)
# ['Chicken Chicken', 'McDonald's', 'Burger King']
```

It's also common to see this as one line:

```
# Removes all duplicates and returns another list
list(set(restaurants))
```

Now any operations that could be performed on the original list can be done again.

Section 8.3: Set of Sets

```
{{1,2}, {3,4}}
```

leads to:

```
TypeError: unhashable type: 'set'
```

Instead, use *frozenset*:

```
{frozenset({1, 2}), frozenset({3, 4})}
```

Section 8.4: Set Operations using Methods and Builtins

We define two sets a and b

```
>>> a = {1, 2, 2, 3, 4}
>>> b = {3, 3, 4, 4, 5}
```

NOTE: `{1}` creates a set of one element, but `{}` creates an empty *dict*. The correct way to create an empty set is `set()`.

Intersection

`a.intersection(b)` returns a new set with elements present in both a and b

```
>>> a.intersection(b)
{3, 4}
```

Union

`a.union(b)` returns a new set with elements present in either a and b

```
>>> a.union(b)
{1, 2, 3, 4, 5}
```

Difference

`a.difference(b)` returns a new set with elements present in a but not in b

```
>>> a.difference(b)
{1, 2}
>>> b.difference(a)
{5}
```

Symmetric Difference

`a.symmetric_difference(b)` returns a new set with elements present in either a or b but not in both

```
>>> a.symmetric_difference(b)
{1, 2, 5}
>>> b.symmetric_difference(a)
{1, 2, 5}
```

NOTE: `a.symmetric_difference(b) == b.symmetric_difference(a)`

Subset and superset

`c.issubset(a)` tests whether each element of c is in a.

`a.issuperset(c)` tests whether each element of c is in a.

```
>>> c = {1, 2}
>>> c.issubset(a)
True
>>> a.issuperset(c)
True
```

The latter operations have equivalent operators as shown below:

Method	Operator
<code>a.intersection(b)</code>	<code>a & b</code>
<code>a.union(b)</code>	<code>a b</code>
<code>a.difference(b)</code>	<code>a - b</code>
<code>a.symmetric_difference(b)</code>	<code>a ^ b</code>
<code>a.issubset(b)</code>	<code>a <= b</code>
<code>a.issuperset(b)</code>	<code>a >= b</code>

Disjoint sets

Sets a and d are disjoint if no element in a is also in d and vice versa.

```
>>> d = {5, 6}
>>> a.isdisjoint(b) # {2, 3, 4} are in both sets
False
>>> a.isdisjoint(d)
True

# This is an equivalent check, but less efficient
>>> len(a & d) == 0
True

# This is even less efficient
>>> a & d == set()
True
```

Testing membership

The builtin `in` keyword searches for occurrences

```
>>> 1 in a
True
>>> 6 in a
False
```

Length

The builtin `len()` function returns the number of elements in the set

```
>>> len(a)
4
>>> len(b)
3
```

Section 8.5: Sets versus multisets

Sets are unordered collections of distinct elements. But sometimes we want to work with unordered collections of elements that are not necessarily distinct and keep track of the elements' multiplicities.

Consider this example:

```
>>> setA = {'a', 'b', 'b', 'c'}
>>> setA
set(['a', 'c', 'b'])
```

By saving the strings `'a'`, `'b'`, `'b'`, `'c'` into a set data structure we've lost the information on the fact that `'b'` occurs twice. Of course saving the elements to a list would retain this information

```
>>> listA = ['a', 'b', 'b', 'c']
>>> listA
['a', 'b', 'b', 'c']
```

but a list data structure introduces an extra unneeded ordering that will slow down our computations.

For implementing multisets Python provides the `Counter` class from the `collections` module (starting from version 2.7):

Python 2.x Version \geq 2.7

```
>>> from collections import Counter
>>> counterA = Counter(['a', 'b', 'b', 'c'])
>>> counterA
Counter({'b': 2, 'a': 1, 'c': 1})
```

Counter is a dictionary where elements are stored as dictionary keys and their counts are stored as dictionary values. And as all dictionaries, it is an unordered collection.

Chapter 9: Simple Mathematical Operators

Numerical types and their metaclasses

The `numbers` module contains the abstract metaclasses for the numerical types:

subclasses	numbers.Number	numbers.Integral	numbers.Rational	numbers.Real	numbers.Complex
bool	✓	✓	✓	✓	✓
int	✓	✓	✓	✓	✓
fractions.Fraction	✓	–	✓	✓	✓
float	✓	–	–	✓	✓
complex	✓	–	–	–	✓
decimal.Decimal	✓	–	–	–	–

Python does common mathematical operators on its own, including integer and float division, multiplication, exponentiation, addition, and subtraction. The `math` module (included in all standard Python versions) offers expanded functionality like trigonometric functions, root operations, logarithms, and many more.

Section 9.1: Division

Python does integer division when both operands are integers. The behavior of Python's division operators have changed from Python 2.x and 3.x (see also Integer Division).

```
a, b, c, d, e = 3, 2, 2.0, -3, 10
```

Python 2.x Version ≤ 2.7

In Python 2 the result of the `'/'` operator depends on the type of the numerator and denominator.

```
a / b          # = 1
a / c          # = 1.5
d / b          # = -2
b / a          # = 0
d / e          # = -1
```

Note that because both `a` and `b` are `ints`, the result is an `int`.

The result is always rounded down (floored).

Because `c` is a float, the result of `a / c` is a `float`.

You can also use the `operator` module:

```
import operator          # the operator module provides 2-argument arithmetic functions
operator.div(a, b)        # = 1
operator.__div__(a, b)    # = 1
```

Python 2.x Version ≥ 2.2

What if you want float division:

Recommended:

```
from __future__ import division # applies Python 3 style division to the entire module
a / b                          # = 1.5
a // b                         # = 1
```

Okay (if you don't want to apply to the whole module):

```
a / (b * 1.0)                  # = 1.5
1.0 * a / b                    # = 1.5
a / b * 1.0                    # = 1.0    (careful with order of operations)

from operator import truediv
truediv(a, b)                  # = 1.5
```

Not recommended (may raise TypeError, eg if argument is complex):

```
float(a) / b                   # = 1.5
a / float(b)                   # = 1.5
```

Python 2.x Version ≥ 2.2

The '//' operator in Python 2 forces floored division regardless of type.

```
a // b                         # = 1
a // c                         # = 1.0
```

Python 3.x Version ≥ 3.0

In Python 3 the / operator performs 'true' division regardless of types. The // operator performs floor division and maintains type.

```
a / b                          # = 1.5
e / b                          # = 5.0
a // b                         # = 1
a // c                         # = 1.0

import operator                # the operator module provides 2-argument arithmetic functions
operator.truediv(a, b)         # = 1.5
operator.floordiv(a, b)        # = 1
operator.floordiv(a, c)        # = 1.0
```

Possible combinations (builtin types):

- `int` and `int` (gives an `int` in Python 2 and a `float` in Python 3)
- `int` and `float` (gives a `float`)
- `int` and `complex` (gives a `complex`)
- `float` and `float` (gives a `float`)
- `float` and `complex` (gives a `complex`)
- `complex` and `complex` (gives a `complex`)

See [PEP 238](#) for more information.

Section 9.2: Addition

```
a, b = 1, 2

# Using the "+" operator:
a + b                      # = 3
```

```
# Using the "in-place" "+=" operator to add and assign:
a += b          # a = 3 (equivalent to a = a + b)

import operator    # contains 2 argument arithmetic functions for the examples

operator.add(a, b)    # = 5 since a is set to 3 right before this line

# The "+=" operator is equivalent to:
a = operator.iadd(a, b)    # a = 5 since a is set to 3 right before this line
```

Possible combinations (builtin types):

- `int` and `int` (gives an `int`)
- `int` and `float` (gives a `float`)
- `int` and `complex` (gives a `complex`)
- `float` and `float` (gives a `float`)
- `float` and `complex` (gives a `complex`)
- `complex` and `complex` (gives a `complex`)

Note: the `+` operator is also used for concatenating strings, lists and tuples:

```
"first string " + "second string"    # = 'first string second string'

[1, 2, 3] + [4, 5, 6]                # = [1, 2, 3, 4, 5, 6]
```

Section 9.3: Exponentiation

```
a, b = 2, 3

(a ** b)          # = 8
pow(a, b)         # = 8

import math
math.pow(a, b)     # = 8.0 (always float; does not allow complex results)

import operator
operator.pow(a, b) # = 8
```

Another difference between the built-in `pow` and `math.pow` is that the built-in `pow` can accept three arguments:

```
a, b, c = 2, 3, 2

pow(2, 3, 2)      # 0, calculates (2 ** 3) % 2, but as per Python docs,
                  # does so more efficiently
```

Special functions

The function `math.sqrt(x)` calculates the square root of `x`.

```
import math
import cmath
c = 4
math.sqrt(c)      # = 2.0 (always float; does not allow complex results)
cmath.sqrt(c)     # = (2+0j) (always complex)
```

To compute other roots, such as a cube root, raise the number to the reciprocal of the degree of the root. This could be done with any of the exponential functions or operator.


```
import math
x = 8
math.pow(x, 1/3) # evaluates to 2.0
x**(1/3) # evaluates to 2.0
```

The function `math.exp(x)` computes e^{**x} .

```
math.exp(0) # 1.0
math.exp(1) # 2.718281828459045 (e)
```

The function `math.expm1(x)` computes $e^{**x} - 1$. When x is small, this gives significantly better precision than `math.exp(x) - 1`.

```
math.expm1(0) # 0.0

math.exp(1e-6) - 1 # 1.0000004999621837e-06
math.expm1(1e-6) # 1.0000005000001665e-06
# exact result # 1.000000500000166666708333341666...
```

Section 9.4: Trigonometric Functions

```
a, b = 1, 2

import math

math.sin(a) # returns the sine of 'a' in radians
# Out: 0.8414709848078965

math.cosh(b) # returns the inverse hyperbolic cosine of 'b' in radians
# Out: 3.7621956910836314

math.atan(math.pi) # returns the arc tangent of 'pi' in radians
# Out: 1.2626272556789115

math.hypot(a, b) # returns the Euclidean norm, same as math.sqrt(a*a + b*b)
# Out: 2.23606797749979
```

Note that `math.hypot(x, y)` is also the length of the vector (or Euclidean distance) from the origin $(0, 0)$ to the point (x, y) .

To compute the Euclidean distance between two points (x_1, y_1) & (x_2, y_2) you can use `math.hypot` as follows

```
math.hypot(x2-x1, y2-y1)
```

To convert from radians -> degrees and degrees -> radians respectively use `math.degrees` and `math.radians`

```
math.degrees(a)
# Out: 57.29577951308232

math.radians(57.29577951308232)
# Out: 1.0
```

Section 9.5: Inplace Operations

It is common within applications to need to have code like this:

```
a = a + 1
```

or

```
a = a * 2
```

There is an effective shortcut for these in place operations:

```
a += 1  
# and  
a *= 2
```

Any mathematic operator can be used before the '=' character to make an inplace operation:

- -= decrement the variable in place
- += increment the variable in place
- *= multiply the variable in place
- /= divide the variable in place
- //= floor divide the variable in place # Python 3
- %= return the modulus of the variable in place
- **= raise to a power in place

Other in place operators exist for the bitwise operators (^, | etc)

Section 9.6: Subtraction

```
a, b = 1, 2  
  
# Using the "-" operator:  
b - a          # = 1  
  
import operator    # contains 2 argument arithmetic functions  
operator.sub(b, a) # = 1
```

Possible combinations (builtin types):

- int and int (gives an int)
- int and float (gives a float)
- int and complex (gives a complex)
- float and float (gives a float)
- float and complex (gives a complex)
- complex and complex (gives a complex)

Section 9.7: Multiplication

```
a, b = 2, 3  
  
a * b          # = 6  
  
import operator
```

```
operator.mul(a, b)    # = 6
```

Possible combinations (builtin types):

- `int` and `int` (gives an `int`)
- `int` and `float` (gives a `float`)
- `int` and `complex` (gives a `complex`)
- `float` and `float` (gives a `float`)
- `float` and `complex` (gives a `complex`)
- `complex` and `complex` (gives a `complex`)

Note: The `*` operator is also used for repeated concatenation of strings, lists, and tuples:

```
3 * 'ab'    # = 'ababab'
3 * ('a', 'b') # = ('a', 'b', 'a', 'b', 'a', 'b')
```

Section 9.8: Logarithms

By default, the `math.log` function calculates the logarithm of a number, base e. You can optionally specify a base as the second argument.

```
import math
import cmath

math.log(5)          # = 1.6094379124341003
# optional base argument. Default is math.e
math.log(5, math.e)  # = 1.6094379124341003
cmath.log(5)         # = (1.6094379124341003+0j)
math.log(1000, 10)   # 3.0 (always returns float)
cmath.log(1000, 10)  # (3+0j)
```

Special variations of the `math.log` function exist for different bases.

```
# Logarithm base e - 1 (higher precision for low values)
math.log1p(5)        # = 1.791759469228055

# Logarithm base 2
math.log2(8)         # = 3.0

# Logarithm base 10
math.log10(100)       # = 2.0
cmath.log10(100)      # = (2+0j)
```

Section 9.9: Modulus

Like in many other languages, Python uses the `%` operator for calculating modulus.

```
3 % 4    # 3
10 % 2   # 0
6 % 4    # 2
```

Or by using the `operator` module:

```
import operator

operator.mod(3, 4)    # 3
```

```
operator.mod(10, 2)    # 0
operator.mod(6, 4)     # 2
```

You can also use negative numbers.

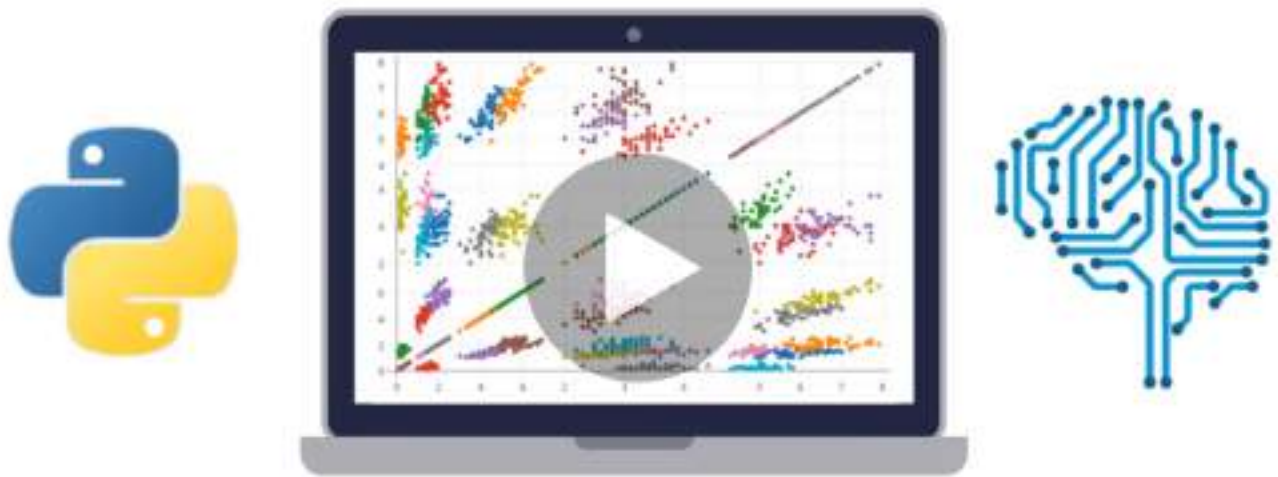
```
-9 % 7    # 5
9 % -7    # -5
-9 % -7   # -2
```

If you need to find the result of integer division and modulus, you can use the `divmod` function as a shortcut:

```
quotient, remainder = divmod(9, 4)
# quotient = 2, remainder = 1 as 4 * 2 + 1 == 9
```

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Chapter 10: Bitwise Operators

Bitwise operations alter binary strings at the bit level. These operations are incredibly basic and are directly supported by the processor. These few operations are necessary in working with device drivers, low-level graphics, cryptography, and network communications. This section provides useful knowledge and examples of Python's bitwise operators.

Section 10.1: Bitwise NOT

The `~` operator will flip all of the bits in the number. Since computers use [signed number representations](#) — most notably, the [two's complement notation](#) to encode negative binary numbers where negative numbers are written with a leading one (1) instead of a leading zero (0).

This means that if you were using 8 bits to represent your two's-complement numbers, you would treat patterns from `0000 0000` to `0111 1111` to represent numbers from 0 to 127 and reserve `1xxx xxxx` to represent negative numbers.

Eight-bit two's-complement numbers

Bits	Unsigned Value	Two's-complement Value
0000 0000	0	0
0000 0001	1	1
0000 0010	2	2
0111 1110	126	126
0111 1111	127	127
1000 0000	128	-128
1000 0001	129	-127
1000 0010	130	-126
1111 1110	254	-2
1111 1111	255	-1

In essence, this means that whereas `1010 0110` has an unsigned value of 166 (arrived at by adding $(128 * 1) + (64 * 0) + (32 * 1) + (16 * 0) + (8 * 0) + (4 * 1) + (2 * 1) + (1 * 0)$), it has a two's-complement value of -90 (arrived at by adding $(128 * 1) - (64 * 0) - (32 * 1) - (16 * 0) - (8 * 0) - (4 * 1) - (2 * 1) - (1 * 0)$, and complementing the value).

In this way, negative numbers range down to -128 (`1000 0000`). Zero (0) is represented as `0000 0000`, and minus one (-1) as `1111 1111`.

In general, though, this means $\sim n = -n - 1$.

```
# 0 = 0b0000 0000
~0
# Out: -1
# -1 = 0b1111 1111

# 1 = 0b0000 0001
~1
# Out: -2
# -2 = 1111 1110

# 2 = 0b0000 0010
~2
```

```
# Out: -3
# -3 = 0b1111 1101

# 123 = 0b0111 1011
~123
# Out: -124
# -124 = 0b1000 0100
```

Note, the overall effect of this operation when applied to positive numbers can be summarized:

```
~n -> -|n+1|
```

And then, when applied to negative numbers, the corresponding effect is:

```
~-n -> |n-1|
```

The following examples illustrate this last rule...

```
# -0 = 0b0000 0000
~-0
# Out: -1
# -1 = 0b1111 1111
# 0 is the obvious exception to this rule, as -0 == 0 always

# -1 = 0b1000 0001
~-1
# Out: 0
# 0 = 0b0000 0000

# -2 = 0b1111 1110
~-2
# Out: 1
# 1 = 0b0000 0001

# -123 = 0b1111 1011
~-123
# Out: 122
# 122 = 0b0111 1010
```

Section 10.2: Bitwise XOR (Exclusive OR)

The `^` operator will perform a binary **XOR** in which a binary 1 is copied if and only if it is the value of exactly **one** operand. Another way of stating this is that the result is 1 only if the operands are different. Examples include:

```
# 0 ^ 0 = 0
# 0 ^ 1 = 1
# 1 ^ 0 = 1
# 1 ^ 1 = 0

# 60 = 0b111100
# 30 = 0b011110
60 ^ 30
# Out: 34
# 34 = 0b100010

bin(60 ^ 30)
```

```
# Out: 0b100010
```

Section 10.3: Bitwise AND

The `&` operator will perform a binary **AND**, where a bit is copied if it exists in **both** operands. That means:

```
# 0 & 0 = 0
# 0 & 1 = 0
# 1 & 0 = 0
# 1 & 1 = 1

# 60 = 0b111100
# 30 = 0b011110
60 & 30
# Out: 28
# 28 = 0b11100

bin(60 & 30)
# Out: 0b11100
```

Section 10.4: Bitwise OR

The `|` operator will perform a binary "or," where a bit is copied if it exists in either operand. That means:

```
# 0 | 0 = 0
# 0 | 1 = 1
# 1 | 0 = 1
# 1 | 1 = 1

# 60 = 0b111100
# 30 = 0b011110
60 | 30
# Out: 62
# 62 = 0b111110

bin(60 | 30)
# Out: 0b111110
```

Section 10.5: Bitwise Left Shift

The `<<` operator will perform a bitwise "left shift," where the left operand's value is moved left by the number of bits given by the right operand.

```
# 2 = 0b10
2 << 2
# Out: 8
# 8 = 0b1000

bin(2 << 2)
# Out: 0b1000
```

Performing a left bit shift of 1 is equivalent to multiplication by 2:

```
7 << 1
# Out: 14
```

Performing a left bit shift of `n` is equivalent to multiplication by `2**n`:


```
3 << 4
# Out: 48
```

Section 10.6: Bitwise Right Shift

The `>>` operator will perform a bitwise "right shift," where the left operand's value is moved right by the number of bits given by the right operand.

```
# 8 = 0b1000
8 >> 2
# Out: 2
# 2 = 0b10

bin(8 >> 2)
# Out: 0b10
```

Performing a right bit shift of 1 is equivalent to integer division by 2:

```
36 >> 1
# Out: 18

15 >> 1
# Out: 7
```

Performing a right bit shift of `n` is equivalent to integer division by `2**n`:

```
48 >> 4
# Out: 3

59 >> 3
# Out: 7
```

Section 10.7: Inplace Operations

All of the Bitwise operators (except `~`) have their own in place versions

```
a = 0b001
a &= 0b010
# a = 0b000

a = 0b001
a |= 0b010
# a = 0b011

a = 0b001
a <= 2
# a = 0b100

a = 0b100
a >= 2
# a = 0b001

a = 0b101
a ^= 0b011
# a = 0b110
```

Chapter 11: Boolean Operators

Section 11.1: `and` and `or` are not guaranteed to return a boolean

When you use `or`, it will either return the first value in the expression if it's true, else it will blindly return the second value. I.e. `or` is equivalent to:

```
def or_(a, b):
    if a:
        return a
    else:
        return b
```

For `and`, it will return its first value if it's false, else it returns the last value:

```
def and_(a, b):
    if not a:
        return a
    else:
        return b
```

Section 11.2: A simple example

In Python you can compare a single element using two binary operators--one on either side:

```
if 3.14 < x < 3.142:
    print("x is near pi")
```

In many (most?) programming languages, this would be evaluated in a way contrary to regular math: $(3.14 < x) < 3.142$, but in Python it is treated like $3.14 < x$ `and` $x < 3.142$, just like most non-programmers would expect.

Section 11.3: Short-circuit evaluation

Python [minimally evaluates](#) Boolean expressions.

```
>>> def true_func():
...     print("true_func()")
...     return True
...
>>> def false_func():
...     print("false_func()")
...     return False
...
>>> true_func() or false_func()
true_func()
True
>>> false_func() or true_func()
false_func()
true_func()
True
>>> true_func() and false_func()
true_func()
false_func()
False
>>> false_func() and false_func()
```

```
false_func()  
False
```

Section 11.4: and

Evaluates to the second argument if and only if both of the arguments are truthy. Otherwise evaluates to the first falsey argument.

```
x = True  
y = True  
z = x and y # z = True  
  
x = True  
y = False  
z = x and y # z = False  
  
x = False  
y = True  
z = x and y # z = False  
  
x = False  
y = False  
z = x and y # z = False  
  
x = 1  
y = 1  
z = x and y # z = y, so z = 1, see `and` and `or` are not guaranteed to be a boolean  
  
x = 0  
y = 1  
z = x and y # z = x, so z = 0 (see above)  
  
x = 1  
y = 0  
z = x and y # z = y, so z = 0 (see above)  
  
x = 0  
y = 0  
z = x and y # z = x, so z = 0 (see above)
```

The 1's in the above example can be changed to any truthy value, and the 0's can be changed to any falsey value.

Section 11.5: or

Evaluates to the first truthy argument if either one of the arguments is truthy. If both arguments are falsey, evaluates to the second argument.

```
x = True  
y = True  
z = x or y # z = True  
  
x = True  
y = False  
z = x or y # z = True  
  
x = False  
y = True  
z = x or y # z = True
```

```

x = False
y = False
z = x or y # z = False

x = 1
y = 1
z = x or y # z = x, so z = 1, see `and` and `or` are not guaranteed to be a boolean

x = 1
y = 0
z = x or y # z = x, so z = 1 (see above)

x = 0
y = 1
z = x or y # z = y, so z = 1 (see above)

x = 0
y = 0
z = x or y # z = y, so z = 0 (see above)

```

The 1's in the above example can be changed to any truthy value, and the 0's can be changed to any falsey value.

Section 11.6: not

It returns the opposite of the following statement:

```

x = True
y = not x # y = False

x = False
y = not x # y = True

```

Chapter 12: Operator Precedence

Python operators have a set **order of precedence**, which determines what operators are evaluated first in a potentially ambiguous expression. For instance, in the expression $3 * 2 + 7$, first 3 is multiplied by 2, and then the result is added to 7, yielding 13. The expression is not evaluated the other way around, because $*$ has a higher precedence than $+$.

Below is a list of operators by precedence, and a brief description of what they (usually) do.

Section 12.1: Simple Operator Precedence Examples in python

Python follows PEMDAS rule. PEMDAS stands for Parentheses, Exponents, Multiplication and Division, and Addition and Subtraction.

Example:

```
>>> a, b, c, d = 2, 3, 5, 7
>>> a ** (b + c) # parentheses
256
>>> a * b ** c # exponent: same as `a * (b ** c)`
7776
>>> a + b * c / d # multiplication / division: same as `a + (b * c / d)`
4.142857142857142
```

Extras: mathematical rules hold, but [not always](#):

```
>>> 300 / 300 * 200
200.0
>>> 300 * 200 / 300
200.0
>>> 1e300 / 1e300 * 1e200
1e+200
>>> 1e300 * 1e200 / 1e300
inf
```

Chapter 13: Variable Scope and Binding

Section 13.1: Nonlocal Variables

Python 3.x Version \geq 3.0

Python 3 added a new keyword called **nonlocal**. The nonlocal keyword adds a scope override to the inner scope. You can read all about it in [PEP 3104](#). This is best illustrated with a couple of code examples. One of the most common examples is to create function that can increment:

```
def counter():
    num = 0
    def incrementer():
        num += 1
        return num
    return incrementer
```

If you try running this code, you will receive an **UnboundLocalError** because the **num** variable is referenced before it is assigned in the innermost function. Let's add nonlocal to the mix:

```
def counter():
    num = 0
    def incrementer():
        nonlocal num
        num += 1
        return num
    return incrementer
```

```
c = counter()
c() # = 1
c() # = 2
c() # = 3
```

Basically **nonlocal** will allow you to assign to variables in an outer scope, but not a global scope. So you can't use **nonlocal** in our counter function because then it would try to assign to a global scope. Give it a try and you will quickly get a **SyntaxError**. Instead you must use **nonlocal** in a nested function.

(Note that the functionality presented here is better implemented using generators.)

Section 13.2: Global Variables

In Python, variables inside functions are considered local if and only if they appear in the left side of an assignment statement, or some other binding occurrence; otherwise such a binding is looked up in enclosing functions, up to the global scope. This is true even if the assignment statement is never executed.

```
x = 'Hi'

def read_x():
    print(x) # x is just referenced, therefore assumed global

read_x() # prints Hi

def read_y():
    print(y) # here y is just referenced, therefore assumed global
```

```

read_y()          # NameError: global name 'y' is not defined

def read_y():
    y = 'Hey'      # y appears in an assignment, therefore it's local
    print(y)       # will find the local y

read_y()          # prints Hey

def read_x_local_fail():
    if False:
        x = 'Hey'  # x appears in an assignment, therefore it's local
    print(x)        # will look for the _local_ z, which is not assigned, and will not be found

read_x_local_fail() # UnboundLocalError: local variable 'x' referenced before assignment

```

Normally, an assignment inside a scope will shadow any outer variables of the same name:

```

x = 'Hi'

def change_local_x():
    x = 'Bye'
    print(x)
change_local_x() # prints Bye
print(x)         # prints Hi

```

Declaring a name **global** means that, for the rest of the scope, any assignments to the name will happen at the module's top level:

```

x = 'Hi'

def change_global_x():
    global x
    x = 'Bye'
    print(x)

change_global_x() # prints Bye
print(x)          # prints Bye

```

The **global** keyword means that assignments will happen at the module's top level, not at the program's top level. Other modules will still need the usual dotted access to variables within the module.

To summarize: in order to know whether a variable *x* is local to a function, you should read the *entire* function:

1. if you've found **global** *x*, then *x* is a **global** variable
2. If you've found **nonlocal** *x*, then *x* belongs to an enclosing function, and is neither local nor global
3. If you've found *x* = 5 or **for** *x* **in** range(3) or some other binding, then *x* is a **local** variable
4. Otherwise *x* belongs to some enclosing scope (function scope, global scope, or builtins)

Section 13.3: Local Variables

If a name is *bound* inside a function, it is by default accessible only within the function:

```

def foo():
    a = 5
    print(a) # ok

print(a) # NameError: name 'a' is not defined

```

Control flow constructs have no impact on the scope (with the exception of **except**), but accessing variable that was not assigned yet is an error:

```
def foo():
    if True:
        a = 5
    print(a) # ok

b = 3
def bar():
    if False:
        b = 5
    print(b) # UnboundLocalError: local variable 'b' referenced before assignment
```

Common binding operations are assignments, **for** loops, and augmented assignments such as `a += 5`

Section 13.4: The del command

This command has several related yet distinct forms.

del v

If `v` is a variable, the command **del v** removes the variable from its scope. For example:

```
x = 5
print(x) # out: 5
del x
print(x) # NameError: name 'x' is not defined
```

Note that **del** is a *binding occurrence*, which means that unless explicitly stated otherwise (using **nonlocal** or **global**), **del v** will make `v` local to the current scope. If you intend to delete `v` in an outer scope, use **nonlocal v** or **global v** in the same scope of the **del v** statement.

In all the following, the intention of a command is a default behavior but is not enforced by the language. A class might be written in a way that invalidates this intention.

del v.name

This command triggers a call to `v.__delattr__(name)`.

The intention is to make the attribute name unavailable. For example:

```
class A:
    pass

a = A()
a.x = 7
print(a.x) # out: 7
del a.x
print(a.x) # error: AttributeError: 'A' object has no attribute 'x'

del v[item]
```

This command triggers a call to `v.__delitem__(item)`.

The intention is that `item` will not belong in the mapping implemented by the object `v`. For example:


```
x = {'a': 1, 'b': 2}
del x['a']
print(x) # out: {'b': 2}
print(x['a']) # error: KeyError: 'a'
del v[a:b]
```

This actually calls `v.__delslice__(a, b)`.

The intention is similar to the one described above, but with slices - ranges of items instead of a single item. For example:

```
x = [0, 1, 2, 3, 4]
del x[1:3]
print(x) # out: [0, 3, 4]
```

See also [Garbage Collection#The del command](#).

Section 13.5: Functions skip class scope when looking up names

Classes have a local scope during definition, but functions inside the class do not use that scope when looking up names. Because lambdas are functions, and comprehensions are implemented using function scope, this can lead to some surprising behavior.

```
a = 'global'

class Fred:
    a = 'class' # class scope
    b = (a for i in range(10)) # function scope
    c = [a for i in range(10)] # function scope
    d = a # class scope
    e = lambda: a # function scope
    f = lambda a=a: a # default argument uses class scope

    @staticmethod # or @classmethod, or regular instance method
    def g(): # function scope
        return a

print(Fred.a) # class
print(next(Fred.b)) # global
print(Fred.c[0]) # class in Python 2, global in Python 3
print(Fred.d) # class
print(Fred.e()) # global
print(Fred.f()) # class
print(Fred.g()) # global
```

Users unfamiliar with how this scope works might expect `b`, `c`, and `e` to print `class`.

From [PEP 227](#):

Names in class scope are not accessible. Names are resolved in the innermost enclosing function scope. If a class definition occurs in a chain of nested scopes, the resolution process skips class definitions.

From Python's documentation on [naming and binding](#):

The scope of names defined in a class block is limited to the class block; it does not extend to the code blocks of methods – this includes comprehensions and generator expressions since they are implemented using a function scope. This means that the following will fail:

```
class A:
    a = 42
    b = list(a + i for i in range(10))
```

This example uses references from [this answer](#) by Martijn Pieters, which contains more in depth analysis of this behavior.

Section 13.6: Local vs Global Scope

What are local and global scope?

All Python variables which are accessible at some point in code are either in *local scope* or in *global scope*.

The explanation is that local scope includes all variables defined in the current function and global scope includes variables defined outside of the current function.

```
foo = 1 # global

def func():
    bar = 2 # local
    print(foo) # prints variable foo from global scope
    print(bar) # prints variable bar from local scope
```

One can inspect which variables are in which scope. Built-in functions `locals()` and `globals()` return the whole scopes as dictionaries.

```
foo = 1

def func():
    bar = 2
    print(globals().keys()) # prints all variable names in global scope
    print(locals().keys()) # prints all variable names in local scope
```

What happens with name clashes?

```
foo = 1

def func():
    foo = 2 # creates a new variable foo in local scope, global foo is not affected

    print(foo) # prints 2

# global variable foo still exists, unchanged:
print(globals()['foo']) # prints 1
print(locals()['foo']) # prints 2
```

To modify a global variable, use keyword **global**:

```
foo = 1

def func():
    global foo
    foo = 2 # this modifies the global foo, rather than creating a local variable
```

The scope is defined for the whole body of the function!

What it means is that a variable will never be global for a half of the function and local afterwards, or vice-versa.

```
foo = 1

def func():
    # This function has a local variable foo, because it is defined down below.
    # So, foo is local from this point. Global foo is hidden.

    print(foo) # raises UnboundLocalError, because local foo is not yet initialized
    foo = 7
    print(foo)
```

Likewise, the opposite:

```
foo = 1

def func():
    # In this function, foo is a global variable from the beginning

    foo = 7 # global foo is modified

    print(foo) # 7
    print(globals()['foo']) # 7

    global foo # this could be anywhere within the function
    print(foo) # 7
```

Functions within functions

There may be many levels of functions nested within functions, but within any one function there is only one local scope for that function and the global scope. There are no intermediate scopes.

```
foo = 1

def f1():
    bar = 1

    def f2():
        baz = 2
        # here, foo is a global variable, baz is a local variable
        # bar is not in either scope
        print(locals().keys()) # ['baz']
        print('bar' in locals()) # False
        print('bar' in globals()) # False

    def f3():
        baz = 3
        print(bar) # bar from f1 is referenced so it enters local scope of f3 (closure)
        print(locals().keys()) # ['bar', 'baz']
        print('bar' in locals()) # True
        print('bar' in globals()) # False

    def f4():
        bar = 4 # a new local bar which hides bar from local scope of f1
        baz = 4
        print(bar)
        print(locals().keys()) # ['bar', 'baz']
        print('bar' in locals()) # True
```

```
print('bar' in globals()) # False
```

global vs nonlocal (Python 3 only)

Both these keywords are used to gain write access to variables which are not local to the current functions.

The **global** keyword declares that a name should be treated as a global variable.

```
foo = 0 # global foo

def f1():
    foo = 1 # a new foo local in f1

    def f2():
        foo = 2 # a new foo local in f2

        def f3():
            foo = 3 # a new foo local in f3
            print(foo) # 3
            foo = 30 # modifies local foo in f3 only

        def f4():
            global foo
            print(foo) # 0
            foo = 100 # modifies global foo
```

On the other hand, **nonlocal** (see Nonlocal Variables), available in Python 3, takes a *local* variable from an enclosing scope into the local scope of current function.

From the [Python documentation on nonlocal](#):

The nonlocal statement causes the listed identifiers to refer to previously bound variables in the nearest enclosing scope excluding globals.

Python 3.x Version ≥ 3.0

```
def f1():

    def f2():
        foo = 2 # a new foo local in f2

        def f3():
            nonlocal foo # foo from f2, which is the nearest enclosing scope
            print(foo) # 2
            foo = 20 # modifies foo from f2!
```

Section 13.7: Binding Occurrence

```
x = 5
x += 7
for x in iterable: pass
```

Each of the above statements is a *binding occurrence* - x become bound to the object denoted by 5. If this statement appears inside a function, then x will be function-local by default. See the "Syntax" section for a list of binding statements.

Chapter 14: Conditionals

Conditional expressions, involving keywords such as `if`, `elif`, and `else`, provide Python programs with the ability to perform different actions depending on a boolean condition: `True` or `False`. This section covers the use of Python conditionals, boolean logic, and ternary statements.

Section 14.1: Conditional Expression (or "The Ternary Operator")

The ternary operator is used for inline conditional expressions. It is best used in simple, concise operations that are easily read.

- The order of the arguments is different from many other languages (such as C, Ruby, Java, etc.), which may lead to bugs when people unfamiliar with Python's "surprising" behaviour use it (they may reverse the order).
- Some find it "unwieldy", since it goes contrary to the normal flow of thought (thinking of the condition first and then the effects).

```
n = 5

"Greater than 2" if n > 2 else "Smaller than or equal to 2"
# Out: 'Greater than 2'
```

The result of this expression will be as it is read in English - if the conditional expression is `True`, then it will evaluate to the expression on the left side, otherwise, the right side.

Ternary operations can also be nested, as here:

```
n = 5
"Hello" if n > 10 else "Goodbye" if n > 5 else "Good day"
```

They also provide a method of including conditionals in lambda functions.

Section 14.2: `if`, `elif`, and `else`

In Python you can define a series of conditionals using `if` for the first one, `elif` for the rest, up until the final (optional) `else` for anything not caught by the other conditionals.

```
number = 5

if number > 2:
    print("Number is bigger than 2.")
elif number < 2: # Optional clause (you can have multiple elifs)
    print("Number is smaller than 2.")
else: # Optional clause (you can only have one else)
    print("Number is 2.")
```

Outputs Number `is` bigger than `2`

Using `else if` instead of `elif` will trigger a syntax error and is not allowed.

Section 14.3: Truth Values

The following values are considered falsey, in that they evaluate to `False` when applied to a boolean operator.

- None
- False
- 0, or any numerical value equivalent to zero, for example 0L, 0.0, 0j
- Empty sequences: '', '', (), []
- Empty mappings: {}
- User-defined types where the `__bool__` or `__len__` methods return 0 or `False`

All other values in Python evaluate to `True`.

Note: A common mistake is to simply check for the Falseness of an operation which returns different Falsey values where the difference matters. For example, using `if foo()` rather than the more explicit `if foo() is None`

Section 14.4: Boolean Logic Expressions

Boolean logic expressions, in addition to evaluating to `True` or `False`, return the *value* that was interpreted as `True` or `False`. It is Pythonic way to represent logic that might otherwise require an if-else test.

And operator

The `and` operator evaluates all expressions and returns the last expression if all expressions evaluate to `True`. Otherwise it returns the first value that evaluates to `False`:

```
>>> 1 and 2
2

>>> 1 and 0
0

>>> 1 and "Hello World"
"Hello World"

>>> "" and "Pancakes"
""
```

Or operator

The `or` operator evaluates the expressions left to right and returns the first value that evaluates to `True` or the last value (if none are `True`).

```
>>> 1 or 2
1

>>> None or 1
1

>>> 0 or []
[]
```

Lazy evaluation

When you use this approach, remember that the evaluation is lazy. Expressions that are not required to be evaluated to determine the result are not evaluated. For example:

```
>>> def print_me():
...     print('I am here!')
>>> 0 and print_me()
0
```

In the above example, `print_me` is never executed because Python can determine the entire expression is `False` when it encounters the `0` (`False`). Keep this in mind if `print_me` needs to execute to serve your program logic.

Testing for multiple conditions

A common mistake when checking for multiple conditions is to apply the logic incorrectly.

This example is trying to check if two variables are each greater than 2. The statement is evaluated as - `if (a) and (b > 2)`. This produces an unexpected result because `bool(a)` evaluates as `True` when `a` is not zero.

```
>>> a = 1
>>> b = 6
>>> if a and b > 2:
...     print('yes')
... else:
...     print('no')
yes
```

Each variable needs to be compared separately.

```
>>> if a > 2 and b > 2:
...     print('yes')
... else:
...     print('no')
no
```

Another, similar, mistake is made when checking if a variable is one of multiple values. The statement in this example is evaluated as - `if (a == 3) or (4) or (6)`. This produces an unexpected result because `bool(4)` and `bool(6)` each evaluate to `True`

```
>>> a = 1
>>> if a == 3 or 4 or 6:
...     print('yes')
... else:
...     print('no')
yes
```

Again each comparison must be made separately

```
>>> if a == 3 or a == 4 or a == 6:
...     print('yes')
... else:
...     print('no')
no
```

Using the `in` operator is the canonical way to write this.

```
>>> if a in (3, 4, 6):
...     print('yes')
... else:
...     print('no')

no
```

Section 14.5: Using the cmp function to get the comparison result of two objects

Python 2 includes a `cmp` function which allows you to determine if one object is less than, equal to, or greater than another object. This function can be used to pick a choice out of a list based on one of those three options.

Suppose you need to print 'greater than' if $x > y$, 'less than' if $x < y$ and 'equal' if $x == y$.

```
['equal', 'greater than', 'less than', ][cmp(x,y)]

# x,y = 1,1 output: 'equal'
# x,y = 1,2 output: 'less than'
# x,y = 2,1 output: 'greater than'
```

`cmp(x,y)` returns the following values

Comparison Result

$x < y$	-1
$x == y$	0
$x > y$	1

This function is removed on Python 3. You can use the [cmp_to_key\(func\)](#) helper function located in `functools` in Python 3 to convert old comparison functions to key functions.

Section 14.6: Else statement

```
if condition:
    body
else:
    body
```

The else statement will execute it's body only if preceding conditional statements all evaluate to False.

```
if True:
    print "It is true!"
else:
    print "This won't get printed.."

# Output: It is true!

if False:
    print "This won't get printed.."
else:
    print "It is false!"

# Output: It is false!
```


Section 14.7: Testing if an object is None and assigning it

You'll often want to assign something to an object if it is `None`, indicating it has not been assigned. We'll use `aDate`.

The simplest way to do this is to use the `is None` test.

```
if aDate is None:
    aDate=datetime.date.today()
```

(Note that it is more Pythonic to say `is None` instead of `== None`.)

But this can be optimized slightly by exploiting the notion that `not None` will evaluate to `True` in a boolean expression. The following code is equivalent:

```
if not aDate:
    aDate=datetime.date.today()
```

But there is a more Pythonic way. The following code is also equivalent:

```
aDate=aDate or datetime.date.today()
```

This does a Short Circuit evaluation. If `aDate` is initialized and is `not None`, then it gets assigned to itself with no net effect. If it `is None`, then the `datetime.date.today()` gets assigned to `aDate`.

Section 14.8: If statement

```
if condition:
    body
```

The `if` statements checks the condition. If it evaluates to `True`, it executes the body of the `if` statement. If it evaluates to `False`, it skips the body.

```
if True:
    print "It is true!"
>> It is true!

if False:
    print "This won't get printed.."
```

The condition can be any valid expression:

```
if 2 + 2 == 4:
    print "I know math!"
>> I know math!
```

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Chapter 15: Comparisons

Parameter	Details
x	First item to be compared
y	Second item to be compared

Section 15.1: Chain Comparisons

You can compare multiple items with multiple comparison operators with chain comparison. For example

```
x > y > z
```

is just a short form of:

```
x > y and y > z
```

This will evaluate to **True** only if both comparisons are **True**.

The general form is

```
a OP b OP c OP d ...
```

Where OP represents one of the multiple comparison operations you can use, and the letters represent arbitrary valid expressions.

Note that `0 != 1 != 0` evaluates to **True**, even though `0 != 0` is **False**. Unlike the common mathematical notation in which `x != y != z` means that x, y and z have different values. Chaining `==` operations has the natural meaning in most cases, since equality is generally transitive.

Style

There is no theoretical limit on how many items and comparison operations you use as long you have proper syntax:

```
1 > -1 < 2 > 0.5 < 100 != 24
```

The above returns **True** if each comparison returns **True**. However, using convoluted chaining is not a good style. A good chaining will be "directional", not more complicated than

```
1 > x > -4 > y != 8
```

Side effects

As soon as one comparison returns **False**, the expression evaluates immediately to **False**, skipping all remaining comparisons.

Note that the expression `exp in a > exp > b` will be evaluated only once, whereas in the case of

```
a > exp and exp > b
```

`exp` will be computed twice if `a > exp` is true.

Section 15.2: Comparison by `is` vs `==`

A common pitfall is confusing the equality comparison operators `is` and `==`.

`a == b` compares the value of `a` and `b`.

`a is b` will compare the *identities* of `a` and `b`.

To illustrate:

```
a = 'Python is fun!'
b = 'Python is fun!'
a == b # returns True
a is b # returns False

a = [1, 2, 3, 4, 5]
b = a      # b references a
a == b     # True
a is b     # True
b = a[:]   # b now references a copy of a
a == b     # True
a is b     # False [!!]
```

Basically, `is` can be thought of as shorthand for `id(a) == id(b)`.

Beyond this, there are quirks of the run-time environment that further complicate things. Short strings and small integers will return `True` when compared with `is`, due to the Python machine attempting to use less memory for identical objects.

```
a = 'short'
b = 'short'
c = 5
d = 5
a is b # True
c is d # True
```

But longer strings and larger integers will be stored separately.

```
a = 'not so short'
b = 'not so short'
c = 1000
d = 1000
a is b # False
c is d # False
```

You should use `is` to test for `None`:

```
if myvar is not None:
    # not None
    pass
if myvar is None:
    # None
    pass
```

A use of `is` is to test for a “sentinel” (i.e. a unique object).

```
sentinel = object()
def myfunc(var=sentinel):
```

```
if var is sentinel:
    # value wasn't provided
    pass
else:
    # value was provided
    pass
```

Section 15.3: Greater than or less than

```
x > y
x < y
```

These operators compare two types of values, they're the less than and greater than operators. For numbers this simply compares the numerical values to see which is larger:

```
12 > 4
# True
12 < 4
# False
1 < 4
# True
```

For strings they will compare lexicographically, which is similar to alphabetical order but not quite the same.

```
"alpha" < "beta"
# True
"gamma" > "beta"
# True
"gamma" < "OMEGA"
# False
```

In these comparisons, lowercase letters are considered 'greater than' uppercase, which is why `"gamma" < "OMEGA"` is false. If they were all uppercase it would return the expected alphabetical ordering result:

```
"GAMMA" < "OMEGA"
# True
```

Each type defines its calculation with the `<` and `>` operators differently, so you should investigate what the operators mean with a given type before using it.

Section 15.4: Not equal to

```
x != y
```

This returns `True` if `x` and `y` are not equal and otherwise returns `False`.

```
12 != 1
# True
12 != '12'
# True
'12' != '12'
# False
```

Section 15.5: Equal To

```
x == y
```

This expression evaluates if x and y are the same value and returns the result as a boolean value. Generally both type and value need to match, so the int 12 is not the same as the string '12'.

```
12 == 12
# True
12 == 1
# False
'12' == '12'
# True
'spam' == 'spam'
# True
'spam' == 'spam '
# False
'12' == 12
# False
```

Note that each type has to define a function that will be used to evaluate if two values are the same. For builtin types these functions behave as you'd expect, and just evaluate things based on being the same value. However custom types could define equality testing as whatever they'd like, including always returning `True` or always returning `False`.

Section 15.6: Comparing Objects

In order to compare the equality of custom classes, you can override `==` and `!=` by defining `__eq__` and `__ne__` methods. You can also override `__lt__` (<), `__le__` (<=), `__gt__` (>), and `__ge__` (>=). Note that you only need to override two comparison methods, and Python can handle the rest (`==` is the same as `not <` and `not >`, etc.)

```
class Foo(object):
    def __init__(self, item):
        self.my_item = item
    def __eq__(self, other):
        return self.my_item == other.my_item

a = Foo(5)
b = Foo(5)
a == b      # True
a != b      # False
a is b      # False
```

Note that this simple comparison assumes that other (the object being compared to) is the same object type. Comparing to another type will throw an error:

```
class Bar(object):
    def __init__(self, item):
        self.other_item = item
    def __eq__(self, other):
        return self.other_item == other.other_item
    def __ne__(self, other):
        return self.other_item != other.other_item

c = Bar(5)
a == c      # throws AttributeError: 'Foo' object has no attribute 'other_item'
```

Checking `isinstance()` or similar will help prevent this (if desired).

Chapter 16: Loops

Parameter	Details
boolean expression	expression that can be evaluated in a boolean context, e.g. <code>x < 10</code>
variable	variable name for the current element from the <code>iterable</code>
iterable	anything that implements iterations

As one of the most basic functions in programming, loops are an important piece to nearly every programming language. Loops enable developers to set certain portions of their code to repeat through a number of loops which are referred to as iterations. This topic covers using multiple types of loops and applications of loops in Python.

Section 16.1: Break and Continue in Loops

break statement

When a **break** statement executes inside a loop, control flow "breaks" out of the loop immediately:

```
i = 0
while i < 7:
    print(i)
    if i == 4:
        print("Breaking from loop")
        break
    i += 1
```

The loop conditional will not be evaluated after the **break** statement is executed. Note that **break** statements are only allowed *inside loops*, syntactically. A **break** statement inside a function cannot be used to terminate loops that called that function.

Executing the following prints every digit until number 4 when the **break** statement is met and the loop stops:

```
0
1
2
3
4
Breaking from loop
```

break statements can also be used inside **for** loops, the other looping construct provided by Python:

```
for i in (0, 1, 2, 3, 4):
    print(i)
    if i == 2:
        break
```

Executing this loop now prints:

```
0
1
2
```

Note that 3 and 4 are not printed since the loop has ended.

If a loop has an **else** clause, it does not execute when the loop is terminated through a **break** statement.

continue statement

A **continue** statement will skip to the next iteration of the loop bypassing the rest of the current block but continuing the loop. As with **break**, **continue** can only appear inside loops:

```
for i in (0, 1, 2, 3, 4, 5):
    if i == 2 or i == 4:
        continue
    print(i)
```

0
1
3
5

Note that 2 and 4 aren't printed, this is because **continue** goes to the next iteration instead of continuing on to **print(i)** when **i == 2** or **i == 4**.

Nested Loops

break and **continue** only operate on a single level of loop. The following example will only break out of the inner **for** loop, not the outer **while** loop:

```
while True:
    for i in range(1, 5):
        if i == 2:
            break    # Will only break out of the inner loop!
```

Python doesn't have the ability to break out of multiple levels of loop at once -- if this behavior is desired, refactoring one or more loops into a function and replacing **break** with **return** may be the way to go.

Use return from within a function as a break

The **return** statement exits from a function, without executing the code that comes after it.

If you have a loop inside a function, using **return** from inside that loop is equivalent to having a **break** as the rest of the code of the loop is not executed (*note that any code after the loop is not executed either*):

```
def break_loop():
    for i in range(1, 5):
        if (i == 2):
            return(i)
        print(i)
    return(5)
```

If you have nested loops, the **return** statement will break all loops:

```
def break_all():
    for j in range(1, 5):
        for i in range(1, 4):
            if i*j == 6:
                return(i)
            print(i*j)
```

will output:

```
1 # 1*1
2 # 1*2
3 # 1*3
4 # 1*4
2 # 2*1
4 # 2*2
# return because 2*3 = 6, the remaining iterations of both loops are not executed
```

Section 16.2: For loops

for loops iterate over a collection of items, such as **list** or **dict**, and run a block of code with each element from the collection.

```
for i in [0, 1, 2, 3, 4]:
    print(i)
```

The above **for** loop iterates over a list of numbers.

Each iteration sets the value of **i** to the next element of the list. So first it will be 0, then 1, then 2, etc. The output will be as follow:

```
0
1
2
3
4
```

range is a function that returns a series of numbers under an iterable form, thus it can be used in **for** loops:

```
for i in range(5):
    print(i)
```

gives the exact same result as the first **for** loop. Note that 5 is not printed as the range here is the first five numbers counting from 0.

Iterable objects and iterators

for loop can iterate on any iterable object which is an object which defines a **__getitem__** or a **__iter__** function. The **__iter__** function returns an iterator, which is an object with a next function that is used to access the next element of the iterable.

Section 16.3: Iterating over lists

To iterate through a list you can use **for**:

```
for x in ['one', 'two', 'three', 'four']:
    print(x)
```

This will print out the elements of the list:

```
one
two
three
four
```

The `range` function generates numbers which are also often used in a for loop.

```
for x in range(1, 6):  
    print(x)
```

The result will be a special [range sequence type](#) in python >=3 and a list in python <=2. Both can be looped through using the for loop.

```
1  
2  
3  
4  
5
```

If you want to loop through both the elements of a list *and* have an index for the elements as well, you can use Python's `enumerate` function:

```
for index, item in enumerate(['one', 'two', 'three', 'four']):  
    print(index, ' :: ', item)
```

`enumerate` will generate tuples, which are unpacked into `index` (an integer) and `item` (the actual value from the list). The above loop will print

```
(0, ' :: ', 'one')  
(1, ' :: ', 'two')  
(2, ' :: ', 'three')  
(3, ' :: ', 'four')
```

Iterate over a list with value manipulation using `map` and `lambda`, i.e. apply lambda function on each element in the list:

```
x = map(lambda e : e.upper(), ['one', 'two', 'three', 'four'])  
print(x)
```

Output:

```
['ONE', 'TWO', 'THREE', 'FOUR'] # Python 2.x
```

NB: in Python 3.x `map` returns an iterator instead of a list so you in case you need a list you have to cast the result `print(list(x))`

Section 16.4: Loops with an "else" clause

The `for` and `while` compound statements (loops) can optionally have an `else` clause (in practice, this usage is fairly rare).

The `else` clause only executes after a `for` loop terminates by iterating to completion, or after a `while` loop terminates by its conditional expression becoming false.

```
for i in range(3):  
    print(i)  
else:  
    print('done')  
  
i = 0
```

```
while i < 3:
    print(i)
    i += 1
else:
    print('done')
```

output:

```
0
1
2
done
```

The **else** clause does *not* execute if the loop terminates some other way (through a **break** statement or by raising an exception):

```
for i in range(2):
    print(i)
    if i == 1:
        break
else:
    print('done')
```

output:

```
0
1
```

Most other programming languages lack this optional **else** clause of loops. The use of the keyword **else** in particular is often considered confusing.

The original concept for such a clause dates back to Donald Knuth and the meaning of the **else** keyword becomes clear if we rewrite a loop in terms of **if** statements and **goto** statements from earlier days before structured programming or from a lower-level assembly language.

For example:

```
while loop_condition():
    ...
    if break_condition():
        break
    ...
```

is equivalent to:

```
# pseudocode

<<start>>:
if loop_condition():
    ...
    if break_condition():
        goto <<end>>
    ...
goto <<start>>
```

```
<<end>>:
```

These remain equivalent if we attach an **else** clause to each of them.

For example:

```
while loop_condition():
    ...
    if break_condition():
        break
    ...
else:
    print('done')
```

is equivalent to:

```
# pseudocode

<<start>>:
if loop_condition():
    ...
    if break_condition():
        goto <<end>>
    ...
    goto <<start>>
else:
    print('done')

<<end>>:
```

A **for** loop with an **else** clause can be understood the same way. Conceptually, there is a loop condition that remains True as long as the iterable object or sequence still has some remaining elements.

Why would one use this strange construct?

The main use case for the **for...else** construct is a concise implementation of search as for instance:

```
a = [1, 2, 3, 4]
for i in a:
    if type(i) is not int:
        print(i)
        break
else:
    print("no exception")
```

To make the **else** in this construct less confusing one can think of it as "*if not break*" or "*if not found*".

Some discussions on this can be found in [\[Python-ideas\] Summary of for...else threads](#), [Why does python use 'else' after for and while loops?](#), and [Else Clauses on Loop Statements](#)

Section 16.5: The Pass Statement

pass is a null statement for when a statement is required by Python syntax (such as within the body of a **for** or **while** loop), but no action is required or desired by the programmer. This can be useful as a placeholder for code that is yet to be written.

```
for x in range(10):
```

```
pass #we don't want to do anything, or are not ready to do anything here, so we'll pass
```

In this example, nothing will happen. The **for** loop will complete without error, but no commands or code will be actioned. **pass** allows us to run our code successfully without having all commands and action fully implemented.

Similarly, **pass** can be used in **while** loops, as well as in selections and function definitions etc.

```
while x == y:  
    pass
```

Section 16.6: Iterating over dictionaries

Considering the following dictionary:

```
d = {"a": 1, "b": 2, "c": 3}
```

To iterate through its keys, you can use:

```
for key in d:  
    print(key)
```

Output:

```
"a"  
"b"  
"c"
```

This is equivalent to:

```
for key in d.keys():  
    print(key)
```

or in Python 2:

```
for key in d.iterkeys():  
    print(key)
```

To iterate through its values, use:

```
for value in d.values():  
    print(value)
```

Output:

```
1  
2  
3
```

To iterate through its keys and values, use:

```
for key, value in d.items():  
    print(key, ":", value)
```

Output:

```
a :: 1
b :: 2
c :: 3
```

Note that in Python 2, `.keys()`, `.values()` and `.items()` return a `list` object. If you simply need to iterate through the result, you can use the equivalent `.iterkeys()`, `.itervalues()` and `.iteritems()`.

The difference between `.keys()` and `.iterkeys()`, `.values()` and `.itervalues()`, `.items()` and `.iteritems()` is that the `iter*` methods are generators. Thus, the elements within the dictionary are yielded one by one as they are evaluated. When a `list` object is returned, all of the elements are packed into a list and then returned for further evaluation.

Note also that in Python 3, Order of items printed in the above manner does not follow any order.

Section 16.7: The "half loop" do-while

Unlike other languages, Python doesn't have a do-until or a do-while construct (this will allow code to be executed once before the condition is tested). However, you can combine a `while True` with a `break` to achieve the same purpose.

```
a = 10
while True:
    a = a-1
    print(a)
    if a<7:
        break
print('Done.')
```

This will print:

```
9
8
7
6
Done.
```

Section 16.8: Looping and Unpacking

If you want to loop over a list of tuples for example:

```
collection = [('a', 'b', 'c'), ('x', 'y', 'z'), ('1', '2', '3')]
```

instead of doing something like this:

```
for item in collection:
    i1 = item[0]
    i2 = item[1]
    i3 = item[2]
    # logic
```

or something like this:

```
for item in collection:
```

```
i1, i2, i3 = item
# logic
```

You can simply do this:

```
for i1, i2, i3 in collection:
    # logic
```

This will also work for *most* types of iterables, not just tuples.

Section 16.9: Iterating different portion of a list with different step size

Suppose you have a long list of elements and you are only interested in every other element of the list. Perhaps you only want to examine the first or last elements, or a specific range of entries in your list. Python has strong indexing built-in capabilities. Here are some examples of how to achieve these scenarios.

Here's a simple list that will be used throughout the examples:

```
lst = ['alpha', 'bravo', 'charlie', 'delta', 'echo']
```

Iteration over the whole list

To iterate over each element in the list, a **for** loop like below can be used:

```
for s in lst:
    print s[:1] # print the first letter
```

The **for** loop assigns *s* for each element of *lst*. This will print:

```
a
b
c
d
e
```

Often you need both the element and the index of that element. The **enumerate** keyword performs that task.

```
for idx, s in enumerate(lst):
    print("%s has an index of %d" % (s, idx))
```

The index *idx* will start with zero and increment for each iteration, while the *s* will contain the element being processed. The previous snippet will output:

```
alpha has an index of 0
bravo has an index of 1
charlie has an index of 2
delta has an index of 3
echo has an index of 4
```

Iterate over sub-list

If we want to iterate over a range (remembering that Python uses zero-based indexing), use the **range** keyword.


```
for i in range(2,4):
    print("lst at %d contains %s" % (i, lst[i]))
```

This would output:

```
lst at 2 contains charlie
lst at 3 contains delta
```

The list may also be sliced. The following slice notation goes from element at index 1 to the end with a step of 2. The two **for** loops give the same result.

```
for s in lst[1::2]:
    print(s)

for i in range(1, len(lst), 2):
    print(lst[i])
```

The above snippet outputs:

```
bravo
delta
```

Indexing and slicing is a topic of its own.

Section 16.10: While Loop

A **while** loop will cause the loop statements to be executed until the loop condition is falsey. The following code will execute the loop statements a total of 4 times.

```
i = 0
while i < 4:
    #loop statements
    i = i + 1
```

While the above loop can easily be translated into a more elegant **for** loop, **while** loops are useful for checking if some condition has been met. The following loop will continue to execute until `myObject` is ready.

```
myObject = anObject()
while myObject.isNotReady():
    myObject.tryToGetReady()
```

while loops can also run without a condition by using numbers (complex or real) or **True**:

```
import cmath

complex_num = cmath.sqrt(-1)
while complex_num:      # You can also replace complex_num with any number, True or a value of any
    type                 # Prints 1j forever
    print(complex_num)
```

If the condition is always true the while loop will run forever (infinite loop) if it is not terminated by a `break` or `return` statement or an exception.

```
while True:
    print "Infinite loop"
```

```
# Infinite loop  
# Infinite loop  
# Infinite loop  
# ...
```

Chapter 17: Arrays

Parameter	Details
b	Represents signed integer of size 1 byte
B	Represents unsigned integer of size 1 byte
c	Represents character of size 1 byte
u	Represents unicode character of size 2 bytes
h	Represents signed integer of size 2 bytes
H	Represents unsigned integer of size 2 bytes
i	Represents signed integer of size 2 bytes
I	Represents unsigned integer of size 2 bytes
w	Represents unicode character of size 4 bytes
l	Represents signed integer of size 4 bytes
L	Represents unsigned integer of size 4 bytes
f	Represents floating point of size 4 bytes
d	Represents floating point of size 8 bytes

"Arrays" in Python are not the arrays in conventional programming languages like C and Java, but closer to lists. A list can be a collection of either homogeneous or heterogeneous elements, and may contain ints, strings or other lists.

Section 17.1: Access individual elements through indexes

Individual elements can be accessed through indexes. Python arrays are zero-indexed. Here is an example:

```
my_array = array('i', [1,2,3,4,5])
print(my_array[1])
# 2
print(my_array[2])
# 3
print(my_array[0])
# 1
```

Section 17.2: Basic Introduction to Arrays

An array is a data structure that stores values of same data type. In Python, this is the main difference between arrays and lists.

While python lists can contain values corresponding to different data types, arrays in python can only contain values corresponding to same data type. In this tutorial, we will understand the Python arrays with few examples.

If you are new to Python, get started with the [Python Introduction](#) article.

To use arrays in python language, you need to import the standard `array` module. This is because array is not a fundamental data type like strings, integer etc. Here is how you can import `array` module in python :

```
from array import *
```

Once you have imported the `array` module, you can declare an array. Here is how you do it:

```
arrayIdentifierName = array(typecode, [Initializers])
```

In the declaration above, `arrayIdentifierName` is the name of array, `typecode` lets python know the type of array and `Initializers` are the values with which array is initialized.

Typecodes are the codes that are used to define the type of array values or the type of array. The table in the parameters section shows the possible values you can use when declaring an array and its type.

Here is a real world example of python array declaration :

```
my_array = array('i', [1,2,3,4])
```

In the example above, typecode used is `i`. This typecode represents signed integer whose size is 2 bytes.

Here is a simple example of an array containing 5 integers

```
from array import *
my_array = array('i', [1,2,3,4,5])
for i in my_array:
    print(i)
# 1
# 2
# 3
# 4
# 5
```

Section 17.3: Append any value to the array using `append()` method

```
my_array = array('i', [1,2,3,4,5])
my_array.append(6)
# array('i', [1, 2, 3, 4, 5, 6])
```

Note that the value 6 was appended to the existing array values.

Section 17.4: Insert value in an array using `insert()` method

We can use the `insert()` method to insert a value at any index of the array. Here is an example :

```
my_array = array('i', [1,2,3,4,5])
my_array.insert(0,0)
#array('i', [0, 1, 2, 3, 4, 5])
```

In the above example, the value 0 was inserted at index 0. Note that the first argument is the index while second argument is the value.

Section 17.5: Extend python array using `extend()` method

A python array can be extended with more than one value using `extend()` method. Here is an example :

```
my_array = array('i', [1,2,3,4,5])
my_extnd_array = array('i', [7,8,9,10])
my_array.extend(my_extnd_array)
# array('i', [1, 2, 3, 4, 5, 7, 8, 9, 10])
```

We see that the array `my_array` was extended with values from `my_extnd_array`.

Section 17.6: Add items from list into array using fromlist() method

Here is an example:

```
my_array = array('i', [1,2,3,4,5])
c=[11,12,13]
my_array.fromlist(c)
# array('i', [1, 2, 3, 4, 5, 11, 12, 13])
```

So we see that the values 11,12 and 13 were added from list c to my_array.

Section 17.7: Remove any array element using remove() method

Here is an example :

```
my_array = array('i', [1,2,3,4,5])
my_array.remove(4)
# array('i', [1, 2, 3, 5])
```

We see that the element 4 was removed from the array.

Section 17.8: Remove last array element using pop() method

pop removes the last element from the array. Here is an example :

```
my_array = array('i', [1,2,3,4,5])
my_array.pop()
# array('i', [1, 2, 3, 4])
```

So we see that the last element (5) was popped out of array.

Section 17.9: Fetch any element through its index using index() method

index() returns first index of the matching value. Remember that arrays are zero-indexed.

```
my_array = array('i', [1,2,3,4,5])
print(my_array.index(5))
# 5
my_array = array('i', [1,2,3,3,5])
print(my_array.index(3))
# 3
```

Note in that second example that only one index was returned, even though the value exists twice in the array

Section 17.10: Reverse a python array using reverse() method

The reverse() method does what the name says it will do - reverses the array. Here is an example :

```
my_array = array('i', [1,2,3,4,5])
my_array.reverse()
# array('i', [5, 4, 3, 2, 1])
```

Section 17.11: Get array buffer information through `buffer_info()` method

This method provides you the array buffer start address in memory and number of elements in array. Here is an example:

```
my_array = array('i', [1,2,3,4,5])
my_array.buffer_info()
(33881712, 5)
```

Section 17.12: Check for number of occurrences of an element using `count()` method

`count()` will return the number of times an element appears in an array. In the following example we see that the value 3 occurs twice.

```
my_array = array('i', [1,2,3,3,5])
my_array.count(3)
# 2
```

Section 17.13: Convert array to string using `tostring()` method

`tostring()` converts the array to a string.

```
my_char_array = array('c', ['g','e','e','k'])
# array('c', 'geek')
print(my_char_array.tostring())
# geek
```

Section 17.14: Convert array to a python list with same elements using `tolist()` method

When you need a Python `list` object, you can utilize the `tolist()` method to convert your array to a list.

```
my_array = array('i', [1,2,3,4,5])
c = my_array.tolist()
# [1, 2, 3, 4, 5]
```

Section 17.15: Append a string to char array using `fromstring()` method

You are able to append a string to a character array using `fromstring()`

```
my_char_array = array('c', ['g','e','e','k'])
my_char_array.fromstring("stuff")
print(my_char_array)
#array('c', 'geekstuff')
```

Chapter 18: Multidimensional arrays

Section 18.1: Lists in lists

A good way to visualize a 2d array is as a list of lists. Something like this:

```
lst=[[1,2,3],[4,5,6],[7,8,9]]
```

here the outer list `lst` has three things in it. each of those things is another list: The first one is: `[1,2,3]`, the second one is: `[4,5,6]` and the third one is: `[7,8,9]`. You can access these lists the same way you would access another other element of a list, like this:

```
print (lst[0])  
#output: [1, 2, 3]  
  
print (lst[1])  
#output: [4, 5, 6]  
  
print (lst[2])  
#output: [7, 8, 9]
```

You can then access the different elements in each of those lists the same way:

```
print (lst[0][0])  
#output: 1  
  
print (lst[0][1])  
#output: 2
```

Here the first number inside the `[]` brackets means get the list in that position. In the above example we used the number `0` to mean get the list in the 0th position which is `[1,2,3]`. The second set of `[]` brackets means get the item in that position from the inner list. In this case we used both `0` and `1` the 0th position in the list we got is the number `1` and in the 1st position it is `2`

You can also set values inside these lists the same way:

```
lst[0]=[10,11,12]
```

Now the list is `[[10,11,12],[4,5,6],[7,8,9]]`. In this example we changed the whole first list to be a completely new list.

```
lst[1][2]=15
```

Now the list is `[[10,11,12],[4,5,15],[7,8,9]]`. In this example we changed a single element inside of one of the inner lists. First we went into the list at position `1` and changed the element within it at position `2`, which was `6` now it's `15`.

Section 18.2: Lists in lists in lists in..

This behaviour can be extended. Here is a 3-dimensional array:

```
[[[111,112,113],[121,122,123],[131,132,133]],[[211,212,213],[221,222,223],[231,232,233]],[[311,312,313],[321,322,323],[331,332,333]]]
```

As is probably obvious, this gets a bit hard to read. Use backslashes to break up the different dimensions:

```
[[ [111, 112, 113], [121, 122, 123], [131, 132, 133]], \
  [[211, 212, 213], [221, 222, 223], [231, 232, 233]], \
  [[311, 312, 313], [321, 322, 323], [331, 332, 333]]]
```

By nesting the lists like this, you can extend to arbitrarily high dimensions.

Accessing is similar to 2D arrays:

```
print(myarray)
print(myarray[1])
print(myarray[2][1])
print(myarray[1][0][2])
etc.
```

And editing is also similar:

```
myarray[1]=new_n-1_d_list
myarray[2][1]=new_n-2_d_list
myarray[1][0][2]=new_n-3_d_list #or a single number if you're dealing with 3D arrays
etc.
```


Chapter 19: Dictionary

Parameter	Details
key	The desired key to lookup
value	The value to set or return

Section 19.1: Introduction to Dictionary

A dictionary is an example of a *key value store* also known as *Mapping* in Python. It allows you to store and retrieve elements by referencing a key. As dictionaries are referenced by key, they have very fast lookups. As they are primarily used for referencing items by key, they are not sorted.

creating a dict

Dictionaries can be initiated in many ways:

literal syntax

```
d = {} # empty dict
d = {'key': 'value'} # dict with initial values
```

Python 3.x Version ≥ 3.5

```
# Also unpacking one or multiple dictionaries with the literal syntax is possible

# makes a shallow copy of otherdict
d = {**otherdict}
# also updates the shallow copy with the contents of the yetanotherdict.
d = {**otherdict, **yetanotherdict}
```

dict comprehension

```
d = {k:v for k,v in [('key', 'value'),]}
```

see also: Comprehensions

built-in class: dict()

```
d = dict() # empty dict
d = dict(key='value') # explicit keyword arguments
d = dict([('key', 'value')]) # passing in a list of key/value pairs
# make a shallow copy of another dict (only possible if keys are only strings!)
d = dict(**otherdict)
```

modifying a dict

To add items to a dictionary, simply create a new key with a value:

```
d['newkey'] = 42
```

It also possible to add `list` and dictionary as value:

```
d['new_list'] = [1, 2, 3]
d['new_dict'] = {'nested_dict': 1}
```

To delete an item, delete the key from the dictionary:

```
del d['newkey']
```

Section 19.2: Avoiding KeyError Exceptions

One common pitfall when using dictionaries is to access a non-existent key. This typically results in a `KeyError` exception

```
mydict = {}
mydict['not there']

Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
KeyError: 'not there'
```

One way to avoid key errors is to use the `dict.get` method, which allows you to specify a default value to return in the case of an absent key.

```
value = mydict.get(key, default_value)
```

Which returns `mydict[key]` if it exists, but otherwise returns `default_value`. Note that this doesn't add key to `mydict`. So if you want to retain that key value pair, you should use `mydict.setdefault(key, default_value)`, which *does* store the key value pair.

```
mydict = {}
print(mydict)
# {}
print(mydict.get("foo", "bar"))
# bar
print(mydict)
# {}
print(mydict.setdefault("foo", "bar"))
# bar
print(mydict)
# {'foo': 'bar'}
```

An alternative way to deal with the problem is catching the exception

```
try:
    value = mydict[key]
except KeyError:
    value = default_value
```

You could also check if the key is in the dictionary.

```
if key in mydict:
    value = mydict[key]
else:
    value = default_value
```

Do note, however, that in multi-threaded environments it is possible for the key to be removed from the dictionary after you check, creating a race condition where the exception can still be thrown.

Another option is to use a subclass of `dict`, `collections.defaultdict`, that has a `default_factory` to create new entries in the dict when given a new_key.

Section 19.3: Iterating Over a Dictionary

If you use a dictionary as an iterator (e.g. in a `for` statement), it traverses the **keys** of the dictionary. For example:

```
d = {'a': 1, 'b': 2, 'c':3}
for key in d:
    print(key, d[key])
# c 3
# b 2
# a 1
```

The same is true when used in a comprehension

```
print([key for key in d])
# ['c', 'b', 'a']
```

Python 3.x Version ≥ 3.0

The `items()` method can be used to loop over both the **key** and **value** simultaneously:

```
for key, value in d.items():
    print(key, value)
# c 3
# b 2
# a 1
```

While the `values()` method can be used to iterate over only the values, as would be expected:

```
for key, value in d.values():
    print(key, value)
# 3
# 2
# 1
```

Python 2.x Version ≥ 2.2

Here, the methods `keys()`, `values()` and `items()` return lists, and there are the three extra methods `iterkeys()`, `itervalues()` and `iteritems()` to return iterators.

Section 19.4: Dictionary with default values

Available in the standard library as [defaultdict](#)

```
from collections import defaultdict

d = defaultdict(int)
d['key']           # 0
d['key'] = 5
d['key']           # 5

d = defaultdict(lambda: 'empty')
d['key']           # 'empty'
d['key'] = 'full'
d['key']           # 'full'
```

[*] Alternatively, if you must use the built-in `dict` class, using `dict.setdefault()` will allow you to create a default whenever you access a key that did not exist before:

```
>>> d = {}
{}
>>> d.setdefault('Another_key', []).append("This worked!")
>>> d
```

```
{'Another_key': ['This worked!']}
```

Keep in mind that if you have many values to add, `dict.setdefault()` will create a new instance of the initial value (in this example a `[]`) every time it's called - which may create unnecessary workloads.

[*] *Python Cookbook, 3rd edition, by David Beazley and Brian K. Jones (O'Reilly). Copyright 2013 David Beazley and Brian Jones, 978-1-449-34037-7.*

Section 19.5: Merging dictionaries

Consider the following dictionaries:

```
>>> fish = {'name': "Nemo", 'hands': "fins", 'special': "gills"}
>>> dog = {'name': "Clifford", 'hands': "paws", 'color': "red"}
```

Python 3.5+

```
>>> fishdog = {**fish, **dog}
>>> fishdog
{'hands': 'paws', 'color': 'red', 'name': 'Clifford', 'special': 'gills'}
```

As this example demonstrates, duplicate keys map to their lattermost value (for example "Clifford" overrides "Nemo").

Python 3.3+

```
>>> from collections import ChainMap
>>> dict(ChainMap(fish, dog))
{'hands': 'fins', 'color': 'red', 'special': 'gills', 'name': 'Nemo'}
```

With this technique the foremost value takes precedence for a given key rather than the last ("Clifford" is thrown out in favor of "Nemo").

Python 2.x, 3.x

```
>>> from itertools import chain
>>> dict(chain(fish.items(), dog.items()))
{'hands': 'paws', 'color': 'red', 'name': 'Clifford', 'special': 'gills'}
```

This uses the lattermost value, as with the `**`-based technique for merging ("Clifford" overrides "Nemo").

```
>>> fish.update(dog)
>>> fish
{'color': 'red', 'hands': 'paws', 'name': 'Clifford', 'special': 'gills'}
```

`dict.update` uses the latter dict to overwrite the previous one.

Section 19.6: Accessing keys and values

When working with dictionaries, it's often necessary to access all the keys and values in the dictionary, either in a `for` loop, a list comprehension, or just as a plain list.

Given a dictionary like:

```
mydict = {
    'a': '1',
```

```
'b': '2'  
}
```

You can get a list of keys using the `keys()` method:

```
print(mydict.keys())  
# Python2: ['a', 'b']  
# Python3: dict_keys(['b', 'a'])
```

If instead you want a list of values, use the `values()` method:

```
print(mydict.values())  
# Python2: ['1', '2']  
# Python3: dict_values(['2', '1'])
```

If you want to work with both the key and its corresponding value, you can use the `items()` method:

```
print(mydict.items())  
# Python2: [('a', '1'), ('b', '2')]  
# Python3: dict_items([('b', '2'), ('a', '1')])
```

NOTE: Because a `dict` is unsorted, `keys()`, `values()`, and `items()` have no sort order. Use `sort()`, `sorted()`, or an `OrderedDict` if you care about the order that these methods return.

Python 2/3 Difference: In Python 3, these methods return special iterable objects, not lists, and are the equivalent of the Python 2 `iterkeys()`, `itervalues()`, and `iteritems()` methods. These objects can be used like lists for the most part, though there are some differences. See [PEP 3106](#) for more details.

Section 19.7: Accessing values of a dictionary

```
dictionary = {"Hello": 1234, "World": 5678}  
print(dictionary["Hello"])
```

The above code will print `1234`.

The string `"Hello"` in this example is called a *key*. It is used to lookup a value in the `dict` by placing the key in square brackets.

The number `1234` is seen after the respective colon in the `dict` definition. This is called the *value* that `"Hello"` maps to in this `dict`.

Looking up a value like this with a key that does not exist will raise a `KeyError` exception, halting execution if uncaught. If we want to access a value without risking a `KeyError`, we can use the `dictionary.get` method. By default if the key does not exist, the method will return `None`. We can pass it a second value to return instead of `None` in the event of a failed lookup.

```
w = dictionary.get("whatever")  
x = dictionary.get("whatever", "nuh-uh")
```

In this example `w` will get the value `None` and `x` will get the value `"nuh-uh"`.

Section 19.8: Creating a dictionary

Rules for creating a dictionary:

- Every key must be **unique** (otherwise it will be overridden)
- Every key must be **hashable** (can use the `hash` function to hash it; otherwise `TypeError` will be thrown)
- There is no particular order for the keys.

```
# Creating and populating it with values
stock = {'eggs': 5, 'milk': 2}

# Or creating an empty dictionary
dictionary = {}

# And populating it after
dictionary['eggs'] = 5
dictionary['milk'] = 2

# Values can also be lists
mydict = {'a': [1, 2, 3], 'b': ['one', 'two', 'three']}

# Use list.append() method to add new elements to the values list
mydict['a'].append(4) # => {'a': [1, 2, 3, 4], 'b': ['one', 'two', 'three']}
mydict['b'].append('four') # => {'a': [1, 2, 3, 4], 'b': ['one', 'two', 'three', 'four']}

# We can also create a dictionary using a list of two-items tuples
iterable = [('eggs', 5), ('milk', 2)]
dictionary = dict(iterables)

# Or using keyword argument:
dictionary = dict(eggs=5, milk=2)

# Another way will be to use the dict.fromkeys:
dictionary = dict.fromkeys((milk, eggs)) # => {'milk': None, 'eggs': None}
dictionary = dict.fromkeys((milk, eggs), (2, 5)) # => {'milk': 2, 'eggs': 5}
```

Section 19.9: Creating an ordered dictionary

You can create an ordered dictionary which will follow a determined order when iterating over the keys in the dictionary.

Use `OrderedDict` from the `collections` module. This will always return the dictionary elements in the original insertion order when iterated over.

```
from collections import OrderedDict

d = OrderedDict()
d['first'] = 1
d['second'] = 2
d['third'] = 3
d['last'] = 4

# Outputs "first 1", "second 2", "third 3", "last 4"
for key in d:
    print(key, d[key])
```

Section 19.10: Unpacking dictionaries using the `**` operator

You can use the `**` keyword argument unpacking operator to deliver the key-value pairs in a dictionary into a function's arguments. A simplified example from the [official documentation](#):

```
>>>
```

```
>>> def parrot(voltage, state, action):
...     print("This parrot wouldn't", action, end=' ')
...     print("if you put", voltage, "volts through it.", end=' ')
...     print("E's", state, "!")
...
>>> d = {"voltage": "four million", "state": "bleedin' demised", "action": "VOOM"}
>>> parrot(**d)

This parrot wouldn't VOOM if you put four million volts through it. E's bleedin' demised !
```

As of Python 3.5 you can also use this syntax to merge an arbitrary number of `dict` objects.

```
>>> fish = {'name': "Nemo", 'hands': "fins", 'special': "gills"}
>>> dog = {'name': "Clifford", 'hands': "paws", 'color': "red"}
>>> fishdog = {**fish, **dog}
>>> fishdog

{'hands': 'paws', 'color': 'red', 'name': 'Clifford', 'special': 'gills'}
```

As this example demonstrates, duplicate keys map to their lattermost value (for example "Clifford" overrides "Nemo").

Section 19.11: The trailing comma

Like lists and tuples, you can include a trailing comma in your dictionary.

```
role = {"By day": "A typical programmer",
        "By night": "Still a typical programmer", }
```

PEP 8 dictates that you should leave a space between the trailing comma and the closing brace.

Section 19.12: The dict() constructor

The `dict()` constructor can be used to create dictionaries from keyword arguments, or from a single iterable of key-value pairs, or from a single dictionary and keyword arguments.

```
dict(a=1, b=2, c=3)           # {'a': 1, 'b': 2, 'c': 3}
dict([('d', 4), ('e', 5), ('f', 6)]) # {'d': 4, 'e': 5, 'f': 6}
dict([('a', 1)], b=2, c=3)      # {'a': 1, 'b': 2, 'c': 3}
dict({'a': 1, 'b': 2}, c=3)     # {'a': 1, 'b': 2, 'c': 3}
```

Section 19.13: Dictionaries Example

Dictionaries map keys to values.

```
car = {}
car["wheels"] = 4
car["color"] = "Red"
car["model"] = "Corvette"
```

Dictionary values can be accessed by their keys.

```
print "Little " + car["color"] + " " + car["model"] + "!"
# This would print out "Little Red Corvette!"
```

Dictionaries can also be created in a JSON style:

```
car = {"wheels": 4, "color": "Red", "model": "Corvette"}
```

Dictionary values can be iterated over:

```
for key in car:
    print key + ": " + car[key]

# wheels: 4
# color: Red
# model: Corvette
```

Section 19.14: All combinations of dictionary values

```
options = {
    "x": ["a", "b"],
    "y": [10, 20, 30]
}
```

Given a dictionary such as the one shown above, where there is a list representing a set of values to explore for the corresponding key. Suppose you want to explore "x"="a" with "y"=10, then "x"="a" with "y"=20, and so on until you have explored all possible combinations.

You can create a list that returns all such combinations of values using the following code.

```
import itertools

options = {
    "x": ["a", "b"],
    "y": [10, 20, 30]}

keys = options.keys()
values = (options[key] for key in keys)
combinations = [dict(zip(keys, combination)) for combination in itertools.product(*values)]
print combinations
```

This gives us the following list stored in the variable combinations:

```
[{'x': 'a', 'y': 10},
 {'x': 'b', 'y': 10},
 {'x': 'a', 'y': 20},
 {'x': 'b', 'y': 20},
 {'x': 'a', 'y': 30},
 {'x': 'b', 'y': 30}]
```


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Chapter 20: List

The Python **List** is a general data structure widely used in Python programs. They are found in other languages, often referred to as *dynamic arrays*. They are both *mutable* and a *sequence* data type that allows them to be *indexed* and *sliced*. The list can contain different types of objects, including other list objects.

Section 20.1: List methods and supported operators

Starting with a given list a:

```
a = [1, 2, 3, 4, 5]
```

1. `append(value)` – appends a new element to the end of the list.

```
# Append values 6, 7, and 7 to the list
a.append(6)
a.append(7)
a.append(7)
# a: [1, 2, 3, 4, 5, 6, 7, 7]

# Append another list
b = [8, 9]
a.append(b)
# a: [1, 2, 3, 4, 5, 6, 7, 7, [8, 9]]

# Append an element of a different type, as list elements do not need to have the same type
my_string = "hello world"
a.append(my_string)
# a: [1, 2, 3, 4, 5, 6, 7, 7, [8, 9], "hello world"]
```

Note that the `append()` method only appends one new element to the end of the list. If you append a list to another list, the list that you append becomes a single element at the end of the first list.

```
# Appending a list to another list
a = [1, 2, 3, 4, 5, 6, 7, 7]
b = [8, 9]
a.append(b)
# a: [1, 2, 3, 4, 5, 6, 7, 7, [8, 9]]
a[8]
# Returns: [8, 9]
```

2. `extend(enumerable)` – extends the list by appending elements from another enumerable.

```
a = [1, 2, 3, 4, 5, 6, 7, 7]
b = [8, 9, 10]

# Extend list by appending all elements from b
a.extend(b)
# a: [1, 2, 3, 4, 5, 6, 7, 7, 8, 9, 10]

# Extend list with elements from a non-list enumerable:
a.extend(range(3))
# a: [1, 2, 3, 4, 5, 6, 7, 7, 8, 9, 10, 0, 1, 2]
```

Lists can also be concatenated with the `+` operator. Note that this does not modify any of the original lists:

```
a = [1, 2, 3, 4, 5, 6] + [7, 7] + b
# a: [1, 2, 3, 4, 5, 6, 7, 7, 8, 9, 10]
```

3. `index(value, [startIndex])` – gets the index of the first occurrence of the input value. If the input value is not in the list a `ValueError` exception is raised. If a second argument is provided, the search is started at that specified index.

```
a.index(7)
# Returns: 6

a.index(49) # ValueError, because 49 is not in a.

a.index(7, 7)
# Returns: 7

a.index(7, 8) # ValueError, because there is no 7 starting at index 8
```

4. `insert(index, value)` – inserts value just before the specified index. Thus after the insertion the new element occupies position index.

```
a.insert(0, 0) # insert 0 at position 0
a.insert(2, 5) # insert 5 at position 2
# a: [0, 1, 5, 2, 3, 4, 5, 6, 7, 7, 8, 9, 10]
```

5. `pop([index])` – removes and returns the item at index. With no argument it removes and returns the last element of the list.

```
a.pop(2)
# Returns: 5
# a: [0, 1, 2, 3, 4, 5, 6, 7, 7, 8, 9, 10]

a.pop(8)
# Returns: 7
# a: [0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10]

# With no argument:
a.pop()
# Returns: 10
# a: [0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
```

6. `remove(value)` – removes the first occurrence of the specified value. If the provided value cannot be found, a `ValueError` is raised.

```
a.remove(0)
a.remove(9)
# a: [1, 2, 3, 4, 5, 6, 7, 8]

a.remove(10)
# ValueError, because 10 is not in a
```

7. `reverse()` – reverses the list in-place and returns `None`.

```
a.reverse()
# a: [8, 7, 6, 5, 4, 3, 2, 1]
```

There are also other ways of reversing a list.

8. `count(value)` – counts the number of occurrences of some value in the list.

```
a.count(7)
# Returns: 2
```

9. `sort()` – sorts the list in numerical and lexicographical order and returns `None`.

```
a.sort()
# a = [1, 2, 3, 4, 5, 6, 7, 8]
# Sorts the list in numerical order
```

Lists can also be reversed when sorted using the `reverse=True` flag in the `sort()` method.

```
a.sort(reverse=True)
# a = [8, 7, 6, 5, 4, 3, 2, 1]
```

If you want to sort by attributes of items, you can use the `key` keyword argument:

```
import datetime

class Person(object):
    def __init__(self, name, birthday, height):
        self.name = name
        self.birthday = birthday
        self.height = height

    def __repr__(self):
        return self.name

l = [Person("John Cena", datetime.date(1992, 9, 12), 175),
     Person("Chuck Norris", datetime.date(1990, 8, 28), 180),
     Person("Jon Skeet", datetime.date(1991, 7, 6), 185)]

l.sort(key=lambda item: item.name)
# l: [Chuck Norris, John Cena, Jon Skeet]

l.sort(key=lambda item: item.birthday)
# l: [Chuck Norris, Jon Skeet, John Cena]

l.sort(key=lambda item: item.height)
# l: [John Cena, Chuck Norris, Jon Skeet]
```

In case of list of dicts the concept is the same:

```
import datetime

l = [{'name': 'John Cena', 'birthday': datetime.date(1992, 9, 12), 'height': 175},
     {'name': 'Chuck Norris', 'birthday': datetime.date(1990, 8, 28), 'height': 180},
     {'name': 'Jon Skeet', 'birthday': datetime.date(1991, 7, 6), 'height': 185}]

l.sort(key=lambda item: item['name'])
# l: [Chuck Norris, John Cena, Jon Skeet]

l.sort(key=lambda item: item['birthday'])
# l: [Chuck Norris, Jon Skeet, John Cena]

l.sort(key=lambda item: item['height'])
# l: [John Cena, Chuck Norris, Jon Skeet]
```

Sort by sub dict:

```
import datetime

l = [{ 'name': 'John Cena', 'birthday': datetime.date(1992, 9, 12), 'size': { 'height': 175, 'weight': 100 }},
      { 'name': 'Chuck Norris', 'birthday': datetime.date(1990, 8, 28), 'size': { 'height': 180, 'weight': 90 }},
      { 'name': 'Jon Skeet', 'birthday': datetime.date(1991, 7, 6), 'size': { 'height': 185, 'weight': 110 }}]

l.sort(key=lambda item: item['size']['height'])
# l: [John Cena, Chuck Norris, Jon Skeet]
```

Better way to sort using attrgetter and itemgetter

Lists can also be sorted using attrgetter and itemgetter functions from the operator module. These can help improve readability and reusability. Here are some examples,

```
from operator import itemgetter, attrgetter

people = [{ 'name': 'chandan', 'age': 20, 'salary': 2000 },
           { 'name': 'chetan', 'age': 18, 'salary': 5000 },
           { 'name': 'guru', 'age': 30, 'salary': 3000 }]
by_age = itemgetter('age')
by_salary = itemgetter('salary')

people.sort(key=by_age) #in-place sorting by age
people.sort(key=by_salary) #in-place sorting by salary
```

itemgetter can also be given an index. This is helpful if you want to sort based on indices of a tuple.

```
list_of_tuples = [(1, 2), (3, 4), (5, 0)]
list_of_tuples.sort(key=itemgetter(1))
print(list_of_tuples) #[(5, 0), (1, 2), (3, 4)]
```

Use the attrgetter if you want to sort by attributes of an object,

```
persons = [Person("John Cena", datetime.date(1992, 9, 12), 175),
           Person("Chuck Norris", datetime.date(1990, 8, 28), 180),
           Person("Jon Skeet", datetime.date(1991, 7, 6), 185)] #reusing Person class from above
example

person.sort(key=attrgetter('name')) #sort by name
by_birthday = attrgetter('birthday')
person.sort(key=by_birthday) #sort by birthday
```

10. `clear()` – removes all items from the list

```
a.clear()
# a = []
```

11. **Replication** – multiplying an existing list by an integer will produce a larger list consisting of that many copies of the original. This can be useful for example for list initialization:

```
b = ["blah"] * 3
# b = ["blah", "blah", "blah"]
```

```
b = [1, 3, 5] * 5
# [1, 3, 5, 1, 3, 5, 1, 3, 5, 1, 3, 5, 1, 3, 5]
```

Take care doing this if your list contains references to objects (eg a list of lists), see Common Pitfalls - List multiplication and common references.

12. **Element deletion** – it is possible to delete multiple elements in the list using the **del** keyword and slice notation:

```
a = list(range(10))
del a[::2]
# a = [1, 3, 5, 7, 9]
del a[-1]
# a = [1, 3, 5, 7]
del a[:]
# a = []
```

13. Copying

The default assignment "=" assigns a reference of the original list to the new name. That is, the original name and new name are both pointing to the same list object. Changes made through any of them will be reflected in another. This is often not what you intended.

```
b = a
a.append(6)
# b: [1, 2, 3, 4, 5, 6]
```

If you want to create a copy of the list you have below options.

You can slice it:

```
new_list = old_list[:]
```

You can use the built in list() function:

```
new_list = list(old_list)
```

You can use generic copy.copy():

```
import copy
new_list = copy.copy(old_list) #inserts references to the objects found in the original.
```

This is a little slower than list() because it has to find out the datatype of old_list first.

If the list contains objects and you want to copy them as well, use generic copy.deepcopy():

```
import copy
new_list = copy.deepcopy(old_list) #inserts copies of the objects found in the original.
```

Obviously the slowest and most memory-needing method, but sometimes unavoidable.

`copy()` – Returns a shallow copy of the list

```
aa = a.copy()
# aa = [1, 2, 3, 4, 5]
```

Section 20.2: Accessing list values

Python lists are zero-indexed, and act like arrays in other languages.

```
lst = [1, 2, 3, 4]
lst[0] # 1
lst[1] # 2
```

Attempting to access an index outside the bounds of the list will raise an `IndexError`.

```
lst[4] # IndexError: list index out of range
```

Negative indices are interpreted as counting from the *end* of the list.

```
lst[-1] # 4
lst[-2] # 3
lst[-5] # IndexError: list index out of range
```

This is functionally equivalent to

```
lst[len(lst)-1] # 4
```

Lists allow to use *slice notation* as `lst[start:end:step]`. The output of the slice notation is a new list containing elements from index `start` to `end-1`. If options are omitted `start` defaults to beginning of list, `end` to end of list and `step` to 1:

```
lst[1:]      # [2, 3, 4]
lst[:3]      # [1, 2, 3]
lst[::2]     # [1, 3]
lst[::-1]    # [4, 3, 2, 1]
lst[-1:0:-1] # [4, 3, 2]
lst[5:8]     # [] since starting index is greater than length of lst, returns empty list
lst[1:10]    # [2, 3, 4] same as omitting ending index
```

With this in mind, you can print a reversed version of the list by calling

```
lst[::-1]    # [4, 3, 2, 1]
```

When using step lengths of negative amounts, the starting index has to be greater than the ending index otherwise the result will be an empty list.

```
lst[3:1:-1] # [4, 3]
```

Using negative step indices are equivalent to the following code:

```
reversed(lst)[0:2] # 0 = 1 -1
                  # 2 = 3 -1
```

The indices used are 1 less than those used in negative indexing and are reversed.

Advanced slicing

When lists are sliced the `__getitem__()` method of the list object is called, with a `slice` object. Python has a builtin slice method to generate slice objects. We can use this to *store* a slice and reuse it later like so,

```
data = 'chandan purohit    22 2000' #assuming data fields of fixed length
name_slice = slice(0,19)
age_slice = slice(19,21)
salary_slice = slice(22,None)

#now we can have more readable slices
print(data[name_slice]) #chandan purohit
print(data[age_slice]) #'22'
print(data[salary_slice]) #'2000'
```

This can be of great use by providing slicing functionality to our objects by overriding `__getitem__` in our class.

Section 20.3: Checking if list is empty

The emptiness of a list is associated to the boolean `False`, so you don't have to check `len(lst) == 0`, but just `lst` or `not lst`

```
lst = []
if not lst:
    print("list is empty")

# Output: list is empty
```

Section 20.4: Iterating over a list

Python supports using a `for` loop directly on a list:

```
my_list = ['foo', 'bar', 'baz']
for item in my_list:
    print(item)

# Output: foo
# Output: bar
# Output: baz
```

You can also get the position of each item at the same time:

```
for (index, item) in enumerate(my_list):
    print('The item in position {} is: {}'.format(index, item))

# Output: The item in position 0 is: foo
# Output: The item in position 1 is: bar
# Output: The item in position 2 is: baz
```

The other way of iterating a list based on the index value:

```
for i in range(0, len(my_list)):
    print(my_list[i])

#output:
>>>
foo
bar
```



```
baz
```

Note that changing items in a list while iterating on it may have unexpected results:

```
for item in my_list:
    if item == 'foo':
        del my_list[0]
    print(item)
```

```
# Output: foo
```

```
# Output: baz
```

In this last example, we deleted the first item at the first iteration, but that caused bar to be skipped.

Section 20.5: Checking whether an item is in a list

Python makes it very simple to check whether an item is in a list. Simply use the `in` operator.

```
lst = ['test', 'twest', 'twest', 'treast']
```

```
'test' in lst
```

```
# Out: True
```

```
'toast' in lst
```

```
# Out: False
```

Note: the `in` operator on sets is asymptotically faster than on lists. If you need to use it many times on potentially large lists, you may want to convert your `list` to a `set`, and test the presence of elements on the `set`.

```
slst = set(lst)
```

```
'test' in slst
```

```
# Out: True
```

Section 20.6: Any and All

You can use `all()` to determine if all the values in an iterable evaluate to True

```
nums = [1, 1, 0, 1]
```

```
all(nums)
```

```
# False
```

```
chars = ['a', 'b', 'c', 'd']
```

```
all(chars)
```

```
# True
```

Likewise, `any()` determines if one or more values in an iterable evaluate to True

```
nums = [1, 1, 0, 1]
```

```
any(nums)
```

```
# True
```

```
vals = [None, None, None, False]
```

```
any(vals)
```

```
# False
```

While this example uses a list, it is important to note these built-ins work with any iterable, including generators.

```
vals = [1, 2, 3, 4]
any(val > 12 for val in vals)
# False
any((val * 2) > 6 for val in vals)
# True
```

Section 20.7: Reversing list elements

You can use the `reversed` function which returns an iterator to the reversed list:

```
In [3]: rev = reversed(numbers)

In [4]: rev
Out[4]: [9, 8, 7, 6, 5, 4, 3, 2, 1]
```

Note that the list "numbers" remains unchanged by this operation, and remains in the same order it was originally.

To reverse in place, you can also use the `reverse` method.

You can also reverse a list (actually obtaining a copy, the original list is unaffected) by using the slicing syntax, setting the third argument (the step) as `-1`:

```
In [1]: numbers = [1, 2, 3, 4, 5, 6, 7, 8, 9]

In [2]: numbers[::-1]
Out[2]: [9, 8, 7, 6, 5, 4, 3, 2, 1]
```

Section 20.8: Concatenate and Merge lists

1. **The simplest way to concatenate** `list1` and `list2`:

```
merged = list1 + list2
```

2. **`zip` returns a list of tuples**, where the *i*-th tuple contains the *i*-th element from each of the argument sequences or iterables:

```
alist = ['a1', 'a2', 'a3']
blist = ['b1', 'b2', 'b3']

for a, b in zip(alist, blist):
    print(a, b)

# Output:
# a1 b1
# a2 b2
# a3 b3
```

If the lists have different lengths then the result will include only as many elements as the shortest one:

```
alist = ['a1', 'a2', 'a3']
blist = ['b1', 'b2', 'b3', 'b4']
for a, b in zip(alist, blist):
    print(a, b)

# Output:
# a1 b1
```

```
# a2 b2
# a3 b3

alist = []
len(list(zip(alist, blist)))

# Output:
# 0
```

For padding lists of unequal length to the longest one with `Nones` use `itertools.zip_longest` (`itertools.izip_longest` in Python 2)

```
alist = ['a1', 'a2', 'a3']
blist = ['b1']
clist = ['c1', 'c2', 'c3', 'c4']

for a,b,c in itertools.zip_longest(alist, blist, clist):
    print(a, b, c)

# Output:
# a1 b1 c1
# a2 None c2
# a3 None c3
# None None c4
```

3. Insert to a specific index values:

```
alist = [123, 'xyz', 'zara', 'abc']
alist.insert(3, [2009])
print("Final List :", alist)
```

Output:

```
Final List : [123, 'xyz', 'zara', 2009, 'abc']
```

Section 20.9: Length of a list

Use `len()` to get the one-dimensional length of a list.

```
len(['one', 'two']) # returns 2

len(['one', [2, 3], 'four']) # returns 3, not 4
```

`len()` also works on strings, dictionaries, and other data structures similar to lists.

Note that `len()` is a built-in function, not a method of a list object.

Also note that the cost of `len()` is `O(1)`, meaning it will take the same amount of time to get the length of a list regardless of its length.

Section 20.10: Remove duplicate values in list

Removing duplicate values in a list can be done by converting the list to a `set` (that is an unordered collection of distinct objects). If a `list` data structure is needed, then the set can be converted back to a list using the function `list()`:

```
names = ["aixk", "duke", "edik", "tofp", "duke"]
list(set(names))
# Out: ['duke', 'tofp', 'aixk', 'edik']
```

Note that by converting a list to a set the original ordering is lost.

To preserve the order of the list one can use an OrderedDict

```
import collections
>>> collections.OrderedDict.fromkeys(names).keys()
# Out: ['aixk', 'duke', 'edik', 'tofp']
```

Section 20.11: Comparison of lists

It's possible to compare lists and other sequences lexicographically using comparison operators. Both operands must be of the same type.

```
[1, 10, 100] < [2, 10, 100]
# True, because 1 < 2
[1, 10, 100] < [1, 10, 100]
# False, because the lists are equal
[1, 10, 100] <= [1, 10, 100]
# True, because the lists are equal
[1, 10, 100] < [1, 10, 101]
# True, because 100 < 101
[1, 10, 100] < [0, 10, 100]
# False, because 0 < 1
```

If one of the lists is contained at the start of the other, the shortest list wins.

```
[1, 10] < [1, 10, 100]
# True
```

Section 20.12: Accessing values in nested list

Starting with a three-dimensional list:

```
alist = [[[1,2],[3,4]], [[5,6,7],[8,9,10], [12, 13, 14]]]
```

Accessing items in the list:

```
print(alist[0][0][1])
#2
#Accesses second element in the first list in the first list

print(alist[1][1][2])
#10
#Accesses the third element in the second list in the second list
```

Performing support operations:

```
alist[0][0].append(11)
print(alist[0][0][2])
#11
#Appends 11 to the end of the first list in the first list
```

Using nested for loops to print the list:

```
for row in alist: #One way to loop through nested lists
    for col in row:
        print(col)
#[1, 2, 11]
#[3, 4]
#[5, 6, 7]
#[8, 9, 10]
#[12, 13, 14]
```

Note that this operation can be used in a list comprehension or even as a generator to produce efficiencies, e.g.:

```
[col for row in alist for col in row]
#[[1, 2, 11], [3, 4], [5, 6, 7], [8, 9, 10], [12, 13, 14]]
```

Not all items in the outer lists have to be lists themselves:

```
alist[1].insert(2, 15)
#Inserts 15 into the third position in the second list
```

Another way to use nested for loops. The other way is better but I've needed to use this on occasion:

```
for row in range(len(alist)): #A less Pythonic way to loop through lists
    for col in range(len(alist[row])):
        print(alist[row][col])
#[1, 2, 11]
#[3, 4]
#[5, 6, 7]
#[8, 9, 10]
#15
#[12, 13, 14]
```

Using slices in nested list:

```
print(alist[1][1:])
#[[8, 9, 10], 15, [12, 13, 14]]
#Slices still work
```

The final list:

```
print(alist)
#[[1, 2, 11], [3, 4]], [[5, 6, 7], [8, 9, 10], 15, [12, 13, 14]]
```

Section 20.13: Initializing a List to a Fixed Number of Elements

For **immutable** elements (e.g. `None`, string literals etc.):

```
my_list = [None] * 10
my_list = ['test'] * 10
```

For **mutable** elements, the same construct will result in all elements of the list referring to the same object, for example, for a set:

```
>>> my_list=[{1}] * 10
```

```
>>> print(my_list)
[{1}, {1}, {1}, {1}, {1}, {1}, {1}, {1}, {1}, {1}]
>>> my_list[0].add(2)
>>> print(my_list)
[{1, 2}, {1, 2}, {1, 2}, {1, 2}, {1, 2}, {1, 2}, {1, 2}, {1, 2}, {1, 2}, {1, 2}]
```

Instead, to initialize the list with a fixed number of **different mutable** objects, use:

```
my_list=[{1} for _ in range(10)]
```

Chapter 21: List comprehensions

List comprehensions in Python are concise, syntactic constructs. They can be utilized to generate lists from other lists by applying functions to each element in the list. The following section explains and demonstrates the use of these expressions.

Section 21.1: List Comprehensions

A [list comprehension](#) creates a new **list** by applying an expression to each element of an iterable. The most basic form is:

```
[ <expression> for <element> in <iterable> ]
```

There's also an optional 'if' condition:

```
[ <expression> for <element> in <iterable> if <condition> ]
```

Each **<element>** in the **<iterable>** is plugged in to the **<expression>** if the (optional) **<condition>** [evaluates to true](#). All results are returned at once in the new list. Generator expressions are evaluated lazily, but list comprehensions evaluate the entire iterator immediately - consuming memory proportional to the iterator's length.

To create a **list** of squared integers:

```
squares = [x * x for x in (1, 2, 3, 4)]  
# squares: [1, 4, 9, 16]
```

The **for** expression sets **x** to each value in turn from **(1, 2, 3, 4)**. The result of the expression **x * x** is appended to an internal **list**. The internal **list** is assigned to the variable **squares** when completed.

Besides a [speed increase](#) (as explained [here](#)), a list comprehension is roughly equivalent to the following for-loop:

```
squares = []  
for x in (1, 2, 3, 4):  
    squares.append(x * x)  
# squares: [1, 4, 9, 16]
```

The expression applied to each element can be as complex as needed:

```
# Get a list of uppercase characters from a string  
[s.upper() for s in "Hello World"]  
# ['H', 'E', 'L', 'L', 'O', ' ', 'W', 'O', 'R', 'L', 'D']  
  
# Strip off any commas from the end of strings in a list  
[w.strip(',') for w in ['these,', 'words,', 'mostly', 'have,commas,']]  
# ['these', 'words', 'mostly', 'have,commas']  
  
# Organize letters in words more reasonably - in an alphabetical order  
sentence = "Beautiful is better than ugly"  
["".join(sorted(word, key = lambda x: x.lower())) for word in sentence.split()]  
# ['aBefiltuu', 'is', 'beertt', 'ahnt', 'gluy']
```

else

else can be used in List comprehension constructs, but be careful regarding the syntax. The if/else clauses should

be used before **for** loop, not after:

```
# create a list of characters in apple, replacing non vowels with '*'
# Ex - 'apple' --> ['a', '*', '*', '*', 'e']

[x for x in 'apple' if x in 'aeiou' else '*']
#SyntaxError: invalid syntax

# When using if/else together use them before the loop
[x if x in 'aeiou' else '*' for x in 'apple']
#['a', '*', '*', '*', 'e']
```

Note this uses a different language construct, a [conditional expression](#), which itself is not part of the [comprehension syntax](#). Whereas the **if** after the **for...in** is a part of list comprehensions and used to *filter* elements from the source iterable.

Double Iteration

Order of double iteration [... **for** x **in** ... **for** y **in** ...] is either natural or counter-intuitive. The rule of thumb is to follow an equivalent **for** loop:

```
def foo(i):
    return i, i + 0.5

for i in range(3):
    for x in foo(i):
        yield str(x)
```

This becomes:

```
[str(x)
    for i in range(3)
    for x in foo(i)
]
```

This can be compressed into one line as `[str(x) for i in range(3) for x in foo(i)]`

In-place Mutation and Other Side Effects

Before using list comprehension, understand the difference between functions called for their side effects (*mutating*, or [in-place](#) functions) which usually return **None**, and functions that return an interesting value.

Many functions (especially [pure](#) functions) simply take an object and return some object. An *in-place* function modifies the existing object, which is called a *side effect*. Other examples include input and output operations such as printing.

`list.sort()` sorts a list *in-place* (meaning that it modifies the original list) and returns the value **None**. Therefore, it won't work as expected in a list comprehension:

```
[x.sort() for x in [[2, 1], [4, 3], [0, 1]]]
# [None, None, None]
```

Instead, `sorted()` returns a sorted **list** rather than sorting in-place:


```
[sorted(x) for x in [[2, 1], [4, 3], [0, 1]]]
# [[1, 2], [3, 4], [0, 1]]
```

Using comprehensions for side-effects is possible, such as I/O or in-place functions. Yet a for loop is usually more readable. While this works in Python 3:

```
[print(x) for x in (1, 2, 3)]
```

Instead use:

```
for x in (1, 2, 3):
    print(x)
```

In some situations, side effect functions *are* suitable for list comprehension. `random.randrange()` has the side effect of changing the state of the random number generator, but it also returns an interesting value. Additionally, `next()` can be called on an iterator.

The following random value generator is not pure, yet makes sense as the random generator is reset every time the expression is evaluated:

```
from random import randrange
[randrange(1, 7) for _ in range(10)]
# [2, 3, 2, 1, 1, 5, 2, 4, 3, 5]
```

Whitespace in list comprehensions

More complicated list comprehensions can reach an undesired length, or become less readable. Although less common in examples, it is possible to break a list comprehension into multiple lines like so:

```
[
    x for x
    in 'foo'
    if x not in 'bar'
]
```

Section 21.2: Conditional List Comprehensions

Given a [list comprehension](#) you can append one or more if conditions to filter values.

```
[<expression> for <element> in <iterable> if <condition>]
```

For each **<element>** in **<iterable>**; if **<condition>** evaluates to **True**, add **<expression>** (usually a function of **<element>**) to the returned list.

For example, this can be used to extract only even numbers from a sequence of integers:

```
[x for x in range(10) if x % 2 == 0]
# Out: [0, 2, 4, 6, 8]
```

[Live demo](#)

The above code is equivalent to:

```
even_numbers = []
```

```
for x in range(10):
    if x % 2 == 0:
        even_numbers.append(x)

print(even_numbers)
# Out: [0, 2, 4, 6, 8]
```

Also, a conditional list comprehension of the form `[e for x in y if c]` (where `e` and `c` are expressions in terms of `x`) is equivalent to `list(filter(lambda x: c, map(lambda x: e, y)))`.

Despite providing the same result, pay attention to the fact that the former example is almost 2x faster than the latter one. For those who are curious, [this](#) is a nice explanation of the reason why.

Note that this is quite different from the `... if ... else ...` conditional expression (sometimes known as a ternary expression) that you can use for the `<expression>` part of the list comprehension. Consider the following example:

```
[x if x % 2 == 0 else None for x in range(10)]
# Out: [0, None, 2, None, 4, None, 6, None, 8, None]
```

[Live demo](#)

Here the conditional expression isn't a filter, but rather an operator determining the value to be used for the list items:

```
<value-if-condition-is-true> if <condition> else <value-if-condition-is-false>
```

This becomes more obvious if you combine it with other operators:

```
[2 * (x if x % 2 == 0 else -1) + 1 for x in range(10)]
# Out: [1, -1, 5, -1, 9, -1, 13, -1, 17, -1]
```

[Live demo](#)

If you are using Python 2.7, `xrange` may be better than `range` for several reasons as described in the [xrange documentation](#).

```
[2 * (x if x % 2 == 0 else -1) + 1 for x in xrange(10)]
# Out: [1, -1, 5, -1, 9, -1, 13, -1, 17, -1]
```

The above code is equivalent to:

```
numbers = []
for x in range(10):
    if x % 2 == 0:
        temp = x
    else:
        temp = -1
    numbers.append(2 * temp + 1)
print(numbers)
# Out: [1, -1, 5, -1, 9, -1, 13, -1, 17, -1]
```

One can combine ternary expressions and `if` conditions. The ternary operator works on the filtered result:

```
[x if x > 2 else '*' for x in range(10) if x % 2 == 0]
# Out: ['*', '*', 4, 6, 8]
```

The same couldn't have been achieved just by ternary operator only:

```
[x if (x > 2 and x % 2 == 0) else '*' for x in range(10)]  
# Out: ['*', '*', '*', '*', 4, '*', 6, '*', 8, '*']
```

See also: *Filters*, which often provide a sufficient alternative to conditional list comprehensions.

Section 21.3: Avoid repetitive and expensive operations using conditional clause

Consider the below list comprehension:

```
>>> def f(x):  
...     import time  
...     time.sleep(.1)      # Simulate expensive function  
...     return x**2  
  
>>> [f(x) for x in range(1000) if f(x) > 10]  
[16, 25, 36, ...]
```

This results in two calls to `f(x)` for 1,000 values of `x`: one call for generating the value and the other for checking the `if` condition. If `f(x)` is a particularly expensive operation, this can have significant performance implications. Worse, if calling `f()` has side effects, it can have surprising results.

Instead, you should evaluate the expensive operation only once for each value of `x` by generating an intermediate iterable (generator expression) as follows:

```
>>> [v for v in (f(x) for x in range(1000)) if v > 10]  
[16, 25, 36, ...]
```

Or, using the builtin [map](#) equivalent:

```
>>> [v for v in map(f, range(1000)) if v > 10]  
[16, 25, 36, ...]
```

Another way that could result in a more readable code is to put the partial result (`v` in the previous example) in an iterable (such as a list or a tuple) and then iterate over it. Since `v` will be the only element in the iterable, the result is that we now have a reference to the output of our slow function computed only once:

```
>>> [v for x in range(1000) for v in [f(x)] if v > 10]  
[16, 25, 36, ...]
```

However, in practice, the logic of code can be more complicated and it's important to keep it readable. In general, a separate generator function is recommended over a complex one-liner:

```
>>> def process_prime_numbers(iterable):  
...     for x in iterable:  
...         if is_prime(x):  
...             yield f(x)  
...  
>>> [x for x in process_prime_numbers(range(1000)) if x > 10]  
[11, 13, 17, 19, ...]
```

Another way to prevent computing `f(x)` multiple times is to use the [@functools.lru_cache\(\)](#) (Python 3.2+) decorator on `f(x)`. This way since the output of `f` for the input `x` has already been computed once, the second

function invocation of the original list comprehension will be as fast as a dictionary lookup. This approach uses [memoization](#) to improve efficiency, which is comparable to using generator expressions.

Say you have to flatten a list

```
l = [[1, 2, 3], [4, 5, 6], [7], [8, 9]]
```

Some of the methods could be:

```
reduce(lambda x, y: x+y, l)
sum(l, [])
list(itertools.chain(*l))
```

However list comprehension would provide the best time complexity.

```
[item for sublist in l for item in sublist]
```

The shortcuts based on + (including the implied use in sum) are, of necessity, $O(L^2)$ when there are L sublists -- as the intermediate result list keeps getting longer, at each step a new intermediate result list object gets allocated, and all the items in the previous intermediate result must be copied over (as well as a few new ones added at the end). So (for simplicity and without actual loss of generality) say you have L sublists of I items each: the first I items are copied back and forth $L-1$ times, the second I items $L-2$ times, and so on; total number of copies is I times the sum of x for x from 1 to L excluded, i.e., $I * (L^2 - L) / 2$.

The list comprehension just generates one list, once, and copies each item over (from its original place of residence to the result list) also exactly once.

Section 21.4: Dictionary Comprehensions

A [dictionary comprehension](#) is similar to a list comprehension except that it produces a dictionary object instead of a list.

A basic example:

Python 2.x Version ≥ 2.7

```
{x: x * x for x in (1, 2, 3, 4)}
# Out: {1: 1, 2: 4, 3: 9, 4: 16}
```

which is just another way of writing:

```
dict((x, x * x) for x in (1, 2, 3, 4))
# Out: {1: 1, 2: 4, 3: 9, 4: 16}
```

As with a list comprehension, we can use a conditional statement inside the dict comprehension to produce only the dict elements meeting some criterion.

Python 2.x Version ≥ 2.7

```
{name: len(name) for name in ('Stack', 'Overflow', 'Exchange') if len(name) > 6}
# Out: {'Exchange': 8, 'Overflow': 8}
```

Or, rewritten using a generator expression.

```
dict((name, len(name)) for name in ('Stack', 'Overflow', 'Exchange') if len(name) > 6)
# Out: {'Exchange': 8, 'Overflow': 8}
```

Starting with a dictionary and using dictionary comprehension as a key-value pair filter

Python 2.x Version \geq 2.7

```
initial_dict = {'x': 1, 'y': 2}
{key: value for key, value in initial_dict.items() if key == 'x'}
# Out: {'x': 1}
```

Switching key and value of dictionary (invert dictionary)

If you have a dict containing simple *hashable* values (duplicate values may have unexpected results):

```
my_dict = {1: 'a', 2: 'b', 3: 'c'}
```

and you wanted to swap the keys and values you can take several approaches depending on your coding style:

- `swapped = {v: k for k, v in my_dict.items()}`
- `swapped = dict((v, k) for k, v in my_dict.iteritems())`
- `swapped = dict(zip(my_dict.values(), my_dict))`
- `swapped = dict(zip(my_dict.values(), my_dict.keys()))`
- `swapped = dict(map(reversed, my_dict.items()))`

```
print(swapped)
# Out: {a: 1, b: 2, c: 3}
```

Python 2.x Version \geq 2.3

If your dictionary is large, consider *importing* [itertools](#) and utilize `izip` or `imap`.

Merging Dictionaries

Combine dictionaries and optionally override old values with a nested dictionary comprehension.

```
dict1 = {'w': 1, 'x': 1}
dict2 = {'x': 2, 'y': 2, 'z': 2}

{k: v for d in [dict1, dict2] for k, v in d.items()}
# Out: {'w': 1, 'x': 2, 'y': 2, 'z': 2}
```

However, dictionary unpacking ([PEP 448](#)) may be a preferred.

Python 3.x Version \geq 3.5

```
{**dict1, **dict2}
# Out: {'w': 1, 'x': 2, 'y': 2, 'z': 2}
```

Note: [dictionary comprehensions](#) were added in Python 3.0 and backported to 2.7+, unlike list comprehensions, which were added in 2.0. Versions < 2.7 can use generator expressions and the `dict()` builtin to simulate the behavior of dictionary comprehensions.

Section 21.5: List Comprehensions with Nested Loops

[List Comprehensions](#) can use nested `for` loops. You can code any number of nested `for` loops within a list comprehension, and each `for` loop may have an optional associated `if` test. When doing so, the order of the `for`

constructs is the same order as when writing a series of nested **for** statements. The general structure of list comprehensions looks like this:

```
[ expression for target1 in iterable1 [if condition1]
    for target2 in iterable2 [if condition2]...
    for targetN in iterableN [if conditionN] ]
```

For example, the following code flattening a list of lists using multiple **for** statements:

```
data = [[1, 2], [3, 4], [5, 6]]
output = []
for each_list in data:
    for element in each_list:
        output.append(element)
print(output)
# Out: [1, 2, 3, 4, 5, 6]
```

can be equivalently written as a list comprehension with multiple **for** constructs:

```
data = [[1, 2], [3, 4], [5, 6]]
output = [element for each_list in data for element in each_list]
print(output)
# Out: [1, 2, 3, 4, 5, 6]
```

[Live Demo](#)

In both the expanded form and the list comprehension, the outer loop (first **for** statement) comes first.

In addition to being more compact, the nested comprehension is also significantly faster.

```
In [1]: data = [[1,2],[3,4],[5,6]]
In [2]: def f():
...:     output=[]
...:     for each_list in data:
...:         for element in each_list:
...:             output.append(element)
...:     return output
In [3]: timeit f()
1000000 loops, best of 3: 1.37 µs per loop
In [4]: timeit [inner for outer in data for inner in outer]
1000000 loops, best of 3: 632 ns per loop
```

The overhead for the function call above is about *140ns*.

Inline ifs are nested similarly, and may occur in any position after the first **for**:

```
data = [[1], [2, 3], [4, 5]]
output = [element for each_list in data
    if len(each_list) == 2
    for element in each_list
    if element != 5]
print(output)
# Out: [2, 3, 4]
```

[Live Demo](#)

For the sake of readability, however, you should consider using traditional *for-loops*. This is especially true when nesting is more than 2 levels deep, and/or the logic of the comprehension is too complex. multiple nested loop list

comprehension could be error prone or it gives unexpected result.

Section 21.6: Generator Expressions

Generator expressions are very similar to list comprehensions. The main difference is that it does not create a full set of results at once; it creates a generator object which can then be iterated over.

For instance, see the difference in the following code:

```
# list comprehension
[x**2 for x in range(10)]
# Output: [0, 1, 4, 9, 16, 25, 36, 49, 64, 81]
```

Python 2.x Version ≥ 2.4

```
# generator comprehension
(x**2 for x in xrange(10))
# Output: <generator object <genexpr> at 0x11b4b7c80>
```

These are two very different objects:

- the list comprehension returns a `list` object whereas the generator comprehension returns a generator.
- generator objects cannot be indexed and makes use of the `next` function to get items in order.

Note: We use `xrange` since it too creates a generator object. If we would use `range`, a list would be created. Also, `xrange` exists only in later version of python 2. In python 3, `range` just returns a generator. For more information, see the *Differences between range and xrange functions* example.

Python 2.x Version ≥ 2.4

```
g = (x**2 for x in xrange(10))
print(g[0])
```

Traceback (most recent call last):

```
File "<stdin>", line 1, in <module>
TypeError: 'generator' object has no attribute '__getitem__'
```

```
g.next() # 0
g.next() # 1
g.next() # 4
...
g.next() # 81
```

```
g.next() # Throws StopIteration Exception
```

Traceback (most recent call last):

```
File "<stdin>", line 1, in <module>
StopIteration
```

Python 3.x Version ≥ 3.0

NOTE: The function `g.next()` should be substituted by `next(g)` and `xrange` with `range` since `Iterator.next()` and `xrange()` do not exist in Python 3.

Although both of these can be iterated in a similar way:

```
for i in [x**2 for x in range(10)]:  
    print(i)
```

```
"""  
Out:  
0  
1  
4  
...  
81  
"""
```

Python 2.x Version \geq 2.4

```
for i in (x**2 for x in xrange(10)):  
    print(i)
```

```
"""  
Out:  
0  
1  
4  
.  
.  
.  
81  
"""
```

Use cases

Generator expressions are lazily evaluated, which means that they generate and return each value only when the generator is iterated. This is often useful when iterating through large datasets, avoiding the need to create a duplicate of the dataset in memory:

```
for square in (x**2 for x in range(1000000)):  
    #do something
```

Another common use case is to avoid iterating over an entire iterable if doing so is not necessary. In this example, an item is retrieved from a remote API with each iteration of `get_objects()`. Thousands of objects may exist, must be retrieved one-by-one, and we only need to know if an object matching a pattern exists. By using a generator expression, when we encounter an object matching the pattern.

```
def get_objects():  
    """Gets objects from an API one by one"""  
    while True:  
        yield get_next_item()  
  
def object_matches_pattern(obj):  
    # perform potentially complex calculation  
    return matches_pattern  
  
def right_item_exists():  
    items = (object_matched_pattern(each) for each in get_objects())  
    for item in items:  
        if item.is_the_right_one:  
  
            return True  
    return False
```


Section 21.7: Set Comprehensions

Set comprehension is similar to list and dictionary comprehension, but it produces a [set](#), which is an unordered collection of unique elements.

Python 2.x Version ≥ 2.7

```
# A set containing every value in range(5):
{x for x in range(5)}
# Out: {0, 1, 2, 3, 4}

# A set of even numbers between 1 and 10:
{x for x in range(1, 11) if x % 2 == 0}
# Out: {2, 4, 6, 8, 10}

# Unique alphabetic characters in a string of text:
text = "When in the Course of human events it becomes necessary for one people..."
{ch.lower() for ch in text if ch.isalpha()}
# Out: set(['a', 'c', 'b', 'e', 'f', 'i', 'h', 'm', 'l', 'o',
#          'n', 'p', 's', 'r', 'u', 't', 'w', 'v', 'y'])
```

[Live Demo](#)

Keep in mind that sets are unordered. This means that the order of the results in the set may differ from the one presented in the above examples.

Note: Set comprehension is available since python 2.7+, unlike list comprehensions, which were added in 2.0. In Python 2.2 to Python 2.6, the `set()` function can be used with a generator expression to produce the same result:

Python 2.x Version ≥ 2.2

```
set(x for x in range(5))
# Out: {0, 1, 2, 3, 4}
```

Section 21.8: Refactoring filter and map to list comprehensions

The `filter` or `map` functions should often be replaced by [list comprehensions](#). Guido Van Rossum describes this well in an [open letter in 2005](#):

`filter(P, S)` is almost always written clearer as `[x for x in S if P(x)]`, and this has the huge advantage that the most common usages involve predicates that are comparisons, e.g. `x==42`, and defining a lambda for that just requires much more effort for the reader (plus the lambda is slower than the list comprehension). Even more so for `map(F, S)` which becomes `[F(x) for x in S]`. Of course, in many cases you'd be able to use generator expressions instead.

The following lines of code are considered "not pythonic" and will raise errors in many python linters.

```
filter(lambda x: x % 2 == 0, range(10)) # even numbers < 10
map(lambda x: 2*x, range(10)) # multiply each number by two
reduce(lambda x,y: x+y, range(10)) # sum of all elements in list
```

Taking what we have learned from the previous quote, we can break down these `filter` and `map` expressions into their equivalent *list comprehensions*; also removing the *lambda* functions from each - making the code more readable in the process.

```
# Filter:
# P(x) = x % 2 == 0
# S = range(10)
[x for x in range(10) if x % 2 == 0]

# Map
# F(x) = 2*x
# S = range(10)
[2*x for x in range(10)]
```

Readability becomes even more apparent when dealing with chaining functions. Where due to readability, the results of one map or filter function should be passed as a result to the next; with simple cases, these can be replaced with a single list comprehension. Further, we can easily tell from the list comprehension what the outcome of our process is, where there is more cognitive load when reasoning about the chained Map & Filter process.

```
# Map & Filter
filtered = filter(lambda x: x % 2 == 0, range(10))
results = map(lambda x: 2*x, filtered)

# List comprehension
results = [2*x for x in range(10) if x % 2 == 0]
```

Refactoring - Quick Reference

- Map

```
map(F, S) == [F(x) for x in S]
```

- Filter

```
filter(P, S) == [x for x in S if P(x)]
```

where *F* and *P* are functions which respectively transform input values and return a *bool*

Section 21.9: Comprehensions involving tuples

The **for** clause of a [list comprehension](#) can specify more than one variable:

```
[x + y for x, y in [(1, 2), (3, 4), (5, 6)]]
# Out: [3, 7, 11]

[x + y for x, y in zip([1, 3, 5], [2, 4, 6])]
# Out: [3, 7, 11]
```

This is just like regular **for** loops:

```
for x, y in [(1,2), (3,4), (5,6)]:
    print(x+y)
# 3
# 7
# 11
```

Note however, if the expression that begins the comprehension is a tuple then it must be parenthesized:

```
[x, y for x, y in [(1, 2), (3, 4), (5, 6)]]
```

```
# SyntaxError: invalid syntax
```

```
[(x, y) for x, y in [(1, 2), (3, 4), (5, 6)]]  
# Out: [(1, 2), (3, 4), (5, 6)]
```

Section 21.10: Counting Occurrences Using Comprehension

When we want to count the number of items in an iterable, that meet some condition, we can use comprehension to produce an idiomatic syntax:

```
# Count the numbers in `range(1000)` that are even and contain the digit `9`:  
print (sum(  
    1 for x in range(1000)  
    if x % 2 == 0 and  
    '9' in str(x)  
))  
# Out: 95
```

The basic concept can be summarized as:

1. Iterate over the elements in `range(1000)`.
2. Concatenate all the needed `if` conditions.
3. Use 1 as *expression* to return a 1 for each item that meets the conditions.
4. Sum up all the 1s to determine number of items that meet the conditions.

Note: Here we are not collecting the 1s in a list (note the absence of square brackets), but we are passing the ones directly to the `sum` function that is summing them up. This is called a *generator expression*, which is similar to a Comprehension.

Section 21.11: Changing Types in a List

Quantitative data is often read in as strings that must be converted to numeric types before processing. The types of all list items can be converted with either a List Comprehension or the `map()` function.

```
# Convert a list of strings to integers.  
items = ["1", "2", "3", "4"]  
[int(item) for item in items]  
# Out: [1, 2, 3, 4]  
  
# Convert a list of strings to float.  
items = ["1", "2", "3", "4"]  
map(float, items)  
# Out:[1.0, 2.0, 3.0, 4.0]
```

Section 21.12: Nested List Comprehensions

Nested list comprehensions, unlike list comprehensions with nested loops, are List comprehensions within a list comprehension. The initial expression can be any arbitrary expression, including another list comprehension.

```
#List Comprehension with nested loop  
[x + y for x in [1, 2, 3] for y in [3, 4, 5]]  
#Out: [4, 5, 6, 5, 6, 7, 6, 7, 8]  
  
#Nested List Comprehension  
[[x + y for x in [1, 2, 3]] for y in [3, 4, 5]]  
#Out: [[4, 5, 6], [5, 6, 7], [6, 7, 8]]
```

The Nested example is equivalent to

```
l = []
for y in [3, 4, 5]:
    temp = []
    for x in [1, 2, 3]:
        temp.append(x + y)
    l.append(temp)
```

One example where a nested comprehension can be used it to transpose a matrix.

```
matrix = [[1,2,3],
          [4,5,6],
          [7,8,9]]

[[row[i] for row in matrix] for i in range(len(matrix))]
# [[1, 4, 7], [2, 5, 8], [3, 6, 9]]
```

Like nested **for** loops, there is no limit to how deep comprehensions can be nested.

```
[[[i + j + k for k in 'cd'] for j in 'ab'] for i in '12']
# Out: [[['1ac', '1ad'], ['1bc', '1bd']], [['2ac', '2ad'], ['2bc', '2bd']]]
```

Section 21.13: Iterate two or more list simultaneously within list comprehension

For iterating more than two lists simultaneously within *list comprehension*, one may use [`zip\(\)`](#) as:

```
>>> list_1 = [1, 2, 3, 4]
>>> list_2 = ['a', 'b', 'c', 'd']
>>> list_3 = ['6', '7', '8', '9']

# Two lists
>>> [(i, j) for i, j in zip(list_1, list_2)]
[(1, 'a'), (2, 'b'), (3, 'c'), (4, 'd')]

# Three lists
>>> [(i, j, k) for i, j, k in zip(list_1, list_2, list_3)]
[(1, 'a', '6'), (2, 'b', '7'), (3, 'c', '8'), (4, 'd', '9')]

# so on ...
```

Chapter 22: List slicing (selecting parts of lists)

Section 22.1: Using the third "step" argument

```
lst = ['a', 'b', 'c', 'd', 'e', 'f', 'g', 'h']

lst[::2]
# Output: ['a', 'c', 'e', 'g']

lst[::3]
# Output: ['a', 'd', 'g']
```

Section 22.2: Selecting a sublist from a list

```
lst = ['a', 'b', 'c', 'd', 'e']

lst[2:4]
# Output: ['c', 'd']

lst[2:]
# Output: ['c', 'd', 'e']

lst[:4]
# Output: ['a', 'b', 'c', 'd']
```

Section 22.3: Reversing a list with slicing

```
a = [1, 2, 3, 4, 5]

# steps through the list backwards (step=-1)
b = a[::-1]

# built-in list method to reverse 'a'
a.reverse()

if a == b:
    print(True)

print(b)

# Output:
# True
# [5, 4, 3, 2, 1]
```

Section 22.4: Shifting a list using slicing

```
def shift_list(array, s):
    """Shifts the elements of a list to the left or right.

    Args:
        array - the list to shift
        s - the amount to shift the list ('+' : right-shift, '-' : left-shift)

    Returns:
        shifted_array - the shifted list
```

```

"""
# calculate actual shift amount (e.g., 11 --> 1 if length of the array is 5)
s %= len(array)

# reverse the shift direction to be more intuitive
s *= -1

# shift array with list slicing
shifted_array = array[s:] + array[:s]

return shifted_array

my_array = [1, 2, 3, 4, 5]

# negative numbers
shift_list(my_array, -7)
>>> [3, 4, 5, 1, 2]

# no shift on numbers equal to the size of the array
shift_list(my_array, 5)
>>> [1, 2, 3, 4, 5]

# works on positive numbers
shift_list(my_array, 3)
>>> [3, 4, 5, 1, 2]

```

Chapter 23: groupby()

Parameter	Details
iterable	Any python iterable
key	Function(criteria) on which to group the iterable

In Python, the `itertools.groupby()` method allows developers to group values of an iterable class based on a specified property into another iterable set of values.

Section 23.1: Example 4

In this example we see what happens when we use different types of iterable.

```
things = [("animal", "bear"), ("animal", "duck"), ("plant", "cactus"), ("vehicle", "harley"), \
          ("vehicle", "speed boat"), ("vehicle", "school bus")]
dic = {}
f = lambda x: x[0]
for key, group in groupby(sorted(things, key=f), f):
    dic[key] = list(group)
dic
```

Results in

```
{'animal': [('animal', 'bear'), ('animal', 'duck')],
'plant': [('plant', 'cactus')],
'vehicle': [('vehicle', 'harley'),
            ('vehicle', 'speed boat'),
            ('vehicle', 'school bus')]}
```

This example below is essentially the same as the one above it. The only difference is that I have changed all the tuples to lists.

```
things = [["animal", "bear"], ["animal", "duck"], ["vehicle", "harley"], ["plant", "cactus"], \
          ["vehicle", "speed boat"], ["vehicle", "school bus"]]
dic = {}
f = lambda x: x[0]
for key, group in groupby(sorted(things, key=f), f):
    dic[key] = list(group)
dic
```

Results

```
{'animal': [['animal', 'bear'], ['animal', 'duck']],
'plant': [['plant', 'cactus']],
'vehicle': [['vehicle', 'harley'],
            ['vehicle', 'speed boat'],
            ['vehicle', 'school bus']]}
```

Section 23.2: Example 2

This example illustrates how the default key is chosen if we do not specify any

```
c = groupby(['goat', 'dog', 'cow', 1, 1, 2, 3, 11, 10, ('persons', 'man', 'woman')])
dic = {}
for k, v in c:
```

```
dic[k] = list(v)
dic
```

Results in

```
{1: [1, 1],
 2: [2],
 3: [3],
 ('persons', 'man', 'woman'): [('persons', 'man', 'woman')],
 'cow': ['cow'],
 'dog': ['dog'],
 10: [10],
 11: [11],
 'goat': ['goat']}
```

Notice here that the tuple as a whole counts as one key in this list

Section 23.3: Example 3

Notice in this example that mulato and camel don't show up in our result. Only the last element with the specified key shows up. The last result for c actually wipes out two previous results. But watch the new version where I have the data sorted first on same key.

```
list_things = ['goat', 'dog', 'donkey', 'mulato', 'cow', 'cat', ('persons', 'man', 'woman'), \
               'wombat', 'mongoose', 'malloo', 'camel']
c = groupby(list_things, key=lambda x: x[0])
dic = {}
for k, v in c:
    dic[k] = list(v)
dic
```

Results in

```
{'c': ['camel'],
 'd': ['dog', 'donkey'],
 'g': ['goat'],
 'm': ['mongoose', 'malloo'],
 'persons': [('persons', 'man', 'woman')],
 'w': ['wombat']}
```

Sorted Version

```
list_things = ['goat', 'dog', 'donkey', 'mulato', 'cow', 'cat', ('persons', 'man', 'woman'), \
               'wombat', 'mongoose', 'malloo', 'camel']
sorted_list = sorted(list_things, key = lambda x: x[0])
print(sorted_list)
print()
c = groupby(sorted_list, key=lambda x: x[0])
dic = {}
for k, v in c:
    dic[k] = list(v)
dic
```

Results in

```
['cow', 'cat', 'camel', 'dog', 'donkey', 'goat', 'mulato', 'mongoose', 'malloo', ('persons', 'man',
'woman'), 'wombat']
```



```
{'c': ['cow', 'cat', 'camel'],  
'd': ['dog', 'donkey'],  
'g': ['goat'],  
'm': ['mulato', 'mongoose', 'malloo'],  
'persons': [('persons', 'man', 'woman')],  
'w': ['wombat']}
```

Chapter 24: Linked lists

A linked list is a collection of nodes, each made up of a reference and a value. Nodes are strung together into a sequence using their references. Linked lists can be used to implement more complex data structures like lists, stacks, queues, and associative arrays.

Section 24.1: Single linked list example

This example implements a linked list with many of the same methods as that of the built-in list object.

```
class Node:
    def __init__(self, val):
        self.data = val
        self.next = None

    def getData(self):
        return self.data

    def getNext(self):
        return self.next

    def setData(self, val):
        self.data = val

    def setNext(self, val):
        self.next = val

class LinkedList:
    def __init__(self):
        self.head = None

    def isEmpty(self):
        """Check if the list is empty"""
        return self.head is None

    def add(self, item):
        """Add the item to the list"""
        new_node = Node(item)
        new_node.setNext(self.head)
        self.head = new_node

    def size(self):
        """Return the length/size of the list"""
        count = 0
        current = self.head
        while current is not None:
            count += 1
            current = current.getNext()
        return count

    def search(self, item):
        """Search for item in list. If found, return True. If not found, return False"""
        current = self.head
        found = False
        while current is not None and not found:
            if current.getData() is item:
                found = True
            else:
                current = current.getNext()
```

```

    return found

def remove(self, item):
    """Remove item from list. If item is not found in list, raise ValueError"""
    current = self.head
    previous = None
    found = False
    while current is not None and not found:
        if current.getData() is item:
            found = True
        else:
            previous = current
            current = current.getNext()
    if found:
        if previous is None:
            self.head = current.getNext()
        else:
            previous.setNext(current.getNext())
    else:
        raise ValueError
    print 'Value not found.'

def insert(self, position, item):
    """
    Insert item at position specified. If position specified is
    out of bounds, raise IndexError
    """
    if position > self.size() - 1:
        raise IndexError
        print "Index out of bounds."
    current = self.head
    previous = None
    pos = 0
    if position is 0:
        self.add(item)
    else:
        new_node = Node(item)
        while pos < position:
            pos += 1
            previous = current
            current = current.getNext()
        previous.setNext(new_node)
        new_node.setNext(current)

def index(self, item):
    """
    Return the index where item is found.
    If item is not found, return None.
    """
    current = self.head
    pos = 0
    found = False
    while current is not None and not found:
        if current.getData() is item:
            found = True
        else:
            current = current.getNext()
            pos += 1
    if found:
        pass
    else:
        pos = None

```

```

    return pos

def pop(self, position = None):
    """
    If no argument is provided, return and remove the item at the head.
    If position is provided, return and remove the item at that position.
    If index is out of bounds, raise IndexError
    """
    if position > self.size():
        print 'Index out of bounds'
        raise IndexError

    current = self.head
    if position is None:
        ret = current.getData()
        self.head = current.getNext()
    else:
        pos = 0
        previous = None
        while pos < position:
            previous = current
            current = current.getNext()
            pos += 1
        ret = current.getData()
        previous.setNext(current.getNext())
    print ret
    return ret

def append(self, item):
    """Append item to the end of the list"""
    current = self.head
    previous = None
    pos = 0
    length = self.size()
    while pos < length:
        previous = current
        current = current.getNext()
        pos += 1
    new_node = Node(item)
    if previous is None:
        new_node.setNext(current)
        self.head = new_node
    else:
        previous.setNext(new_node)

def printList(self):
    """Print the list"""
    current = self.head
    while current is not None:
        print current.getData()
        current = current.getNext()

```

Usage functions much like that of the built-in list.

```

l1 = LinkedList()
l1.add('l')
l1.add('H')
l1.insert(1, 'e')
l1.append('l')
l1.append('o')
l1.printList()

```


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Chapter 25: Linked List Node

Section 25.1: Write a simple Linked List Node in python

A linked list is either:

- the empty list, represented by None, or
- a node that contains a cargo object and a reference to a linked list.

```
#!/usr/bin/env python

class Node:
    def __init__(self, cargo=None, next=None):
        self.car = cargo
        self.cdr = next
    def __str__(self):
        return str(self.car)

def display(lst):
    if lst:
        w("%s " % lst)
        display(lst.cdr)
    else:
        w("nil\n")
```

Chapter 26: Filter

Parameter	Details
function	<i>callable</i> that determines the condition or None then use the identity function for filtering (<i>positional-only</i>)
iterable	iterable that will be filtered (<i>positional-only</i>)

Section 26.1: Basic use of filter

To **filter** discards elements of a sequence based on some criteria:

```
names = ['Fred', 'Wilma', 'Barney']
```

```
def long_name(name):  
    return len(name) > 5
```

Python 2.x Version \geq 2.0

```
filter(long_name, names)  
# Out: ['Barney']
```

```
[name for name in names if len(name) > 5] # equivalent list comprehension  
# Out: ['Barney']
```

```
from itertools import ifilter  
ifilter(long_name, names) # as generator (similar to python 3.x filter builtin)  
# Out: <itertools.ifilter at 0x4197e10>  
list(ifilter(long_name, names)) # equivalent to filter with lists  
# Out: ['Barney']
```

```
(name for name in names if len(name) > 5) # equivalent generator expression  
# Out: <generator object <genexpr> at 0x000000003FD5D38>
```

Python 2.x Version \geq 2.6

```
# Besides the options for older python 2.x versions there is a future_builtin function:  
from future_builtins import filter  
filter(long_name, names) # identical to itertools.ifilter  
# Out: <itertools.ifilter at 0x3eb0ba8>
```

Python 3.x Version \geq 3.0

```
filter(long_name, names) # returns a generator  
# Out: <filter at 0x1fc6e443470>  
list(filter(long_name, names)) # cast to list  
# Out: ['Barney']
```

```
(name for name in names if len(name) > 5) # equivalent generator expression  
# Out: <generator object <genexpr> at 0x000001C6F49BF4C0>
```

Section 26.2: Filter without function

If the function parameter is **None**, then the identity function will be used:

```
list(filter(None, [1, 0, 2, [], '', 'a'])) # discards 0, [] and ''  
# Out: [1, 2, 'a']
```

Python 2.x Version \geq 2.0.1

```
[i for i in [1, 0, 2, [], '', 'a'] if i] # equivalent list comprehension
```

Python 3.x Version \geq 3.0.0


```
(i for i in [1, 0, 2, [], '', 'a'] if i) # equivalent generator expression
```

Section 26.3: Filter as short-circuit check

`filter` (python 3.x) and `ifilter` (python 2.x) return a generator so they can be very handy when creating a short-circuit test like `or` or `and`:

Python 2.x Version $\geq 2.0.1$

```
# not recommended in real use but keeps the example short:
from itertools import ifilter as filter
```

Python 2.x Version $\geq 2.6.1$

```
from future_builtins import filter
```

To find the first element that is smaller than 100:

```
car_shop = [('Toyota', 1000), ('rectangular tire', 80), ('Porsche', 5000)]
def find_something_smaller_than(name_value_tuple):
    print('Check {0}, {1}$'.format(*name_value_tuple))
    return name_value_tuple[1] < 100
next(filter(find_something_smaller_than, car_shop))
# Print: Check Toyota, 1000$
#       Check rectangular tire, 80$
# Out: ('rectangular tire', 80)
```

The `next`-function gives the next (in this case first) element of and is therefore the reason why it's short-circuit.

Section 26.4: Complementary function: `filterfalse`, `ifilterfalse`

There is a complementary function for `filter` in the `itertools`-module:

Python 2.x Version $\geq 2.0.1$

```
# not recommended in real use but keeps the example valid for python 2.x and python 3.x
from itertools import ifilterfalse as filterfalse
```

Python 3.x Version $\geq 3.0.0$

```
from itertools import filterfalse
```

which works exactly like the *generator* `filter` but keeps only the elements that are `False`:

```
# Usage without function (None):
list(filterfalse(None, [1, 0, 2, [], '', 'a'])) # discards 1, 2, 'a'
# Out: [0, [], '']
```

```
# Usage with function
names = ['Fred', 'Wilma', 'Barney']

def long_name(name):
    return len(name) > 5

list(filterfalse(long_name, names))
# Out: ['Fred', 'Wilma']
```

```
# Short-circuit usage with next:
car_shop = [('Toyota', 1000), ('rectangular tire', 80), ('Porsche', 5000)]
def find_something_smaller_than(name_value_tuple):
```

```
print('Check {0}, {1}$'.format(*name_value_tuple)
      return name_value_tuple[1] < 100
next(filterfalse(find_something_smaller_than, car_shop))
# Print: Check Toyota, 1000$
# Out: ('Toyota', 1000)
```

```
# Using an equivalent generator:
car_shop = [('Toyota', 1000), ('rectangular tire', 80), ('Porsche', 5000)]
generator = (car for car in car_shop if not car[1] < 100)
next(generator)
```

Chapter 27: Heapq

Section 27.1: Largest and smallest items in a collection

To find the largest items in a collection, `heapq` module has a function called `nlargest`, we pass it two arguments, the first one is the number of items that we want to retrieve, the second one is the collection name:

```
import heapq

numbers = [1, 4, 2, 100, 20, 50, 32, 200, 150, 8]
print(heapq.nlargest(4, numbers)) # [200, 150, 100, 50]
```

Similarly, to find the smallest items in a collection, we use `nsmallest` function:

```
print(heapq.nsmallest(4, numbers)) # [1, 2, 4, 8]
```

Both `nlargest` and `nsmallest` functions take an optional argument (key parameter) for complicated data structures. The following example shows the use of `age` property to retrieve the oldest and the youngest people from `people` dictionary:

```
people = [
    {'firstname': 'John', 'lastname': 'Doe', 'age': 30},
    {'firstname': 'Jane', 'lastname': 'Doe', 'age': 25},
    {'firstname': 'Janie', 'lastname': 'Doe', 'age': 10},
    {'firstname': 'Jane', 'lastname': 'Roe', 'age': 22},
    {'firstname': 'Johnny', 'lastname': 'Doe', 'age': 12},
    {'firstname': 'John', 'lastname': 'Roe', 'age': 45}
]

oldest = heapq.nlargest(2, people, key=lambda s: s['age'])
print(oldest)
# Output: [{'firstname': 'John', 'age': 45, 'lastname': 'Roe'}, {'firstname': 'John', 'age': 30,
'lastname': 'Doe'}]

youngest = heapq.nsmallest(2, people, key=lambda s: s['age'])
print(youngest)
# Output: [{'firstname': 'Janie', 'age': 10, 'lastname': 'Doe'}, {'firstname': 'Johnny', 'age': 12,
'lastname': 'Doe'}]
```

Section 27.2: Smallest item in a collection

The most interesting property of a heap is that its smallest element is always the first element: `heap[0]`

```
import heapq

numbers = [10, 4, 2, 100, 20, 50, 32, 200, 150, 8]

heapq.heapify(numbers)
print(numbers)
# Output: [2, 4, 10, 100, 8, 50, 32, 200, 150, 20]

heapq.heappop(numbers) # 2
print(numbers)
# Output: [4, 8, 10, 100, 20, 50, 32, 200, 150]
```

```
heapq.heappop(numbers) # 4  
print(numbers)  
# Output: [8, 20, 10, 100, 150, 50, 32, 200]
```

Chapter 28: Tuple

A tuple is an immutable list of values. Tuples are one of Python's simplest and most common collection types, and can be created with the comma operator (`value = 1, 2, 3`).

Section 28.1: Tuple

Syntactically, a tuple is a comma-separated list of values:

```
t = 'a', 'b', 'c', 'd', 'e'
```

Although not necessary, it is common to enclose tuples in parentheses:

```
t = ('a', 'b', 'c', 'd', 'e')
```

Create an empty tuple with parentheses:

```
t0 = ()  
type(t0)           # <type 'tuple'>
```

To create a tuple with a single element, you have to include a final comma:

```
t1 = 'a',  
type(t1)           # <type 'tuple'>
```

Note that a single value in parentheses is not a tuple:

```
t2 = ('a')  
type(t2)           # <type 'str'>
```

To create a singleton tuple it is necessary to have a trailing comma.

```
t2 = ('a',)  
type(t2)           # <type 'tuple'>
```

Note that for singleton tuples it's recommended (see [PEP8 on trailing commas](#)) to use parentheses. Also, no white space after the trailing comma (see [PEP8 on whitespaces](#))

```
t2 = ('a',)         # PEP8-compliant  
t2 = 'a',           # this notation is not recommended by PEP8  
t2 = ('a', )        # this notation is not recommended by PEP8
```

Another way to create a tuple is the built-in function `tuple`.

```
t = tuple('lupins')  
print(t)           # ('l', 'u', 'p', 'i', 'n', 's')  
t = tuple(range(3))  
print(t)           # (0, 1, 2)
```

These examples are based on material from the book [Think Python by Allen B. Downey](#).

Section 28.2: Tuples are immutable

One of the main differences between `lists` and `tuples` in Python is that tuples are immutable, that is, one cannot add or modify items once the tuple is initialized. For example:

```
>>> t = (1, 4, 9)
>>> t[0] = 2
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: 'tuple' object does not support item assignment
```

Similarly, tuples don't have `.append` and `.extend` methods as `list` does. Using `+=` is possible, but it changes the binding of the variable, and not the tuple itself:

```
>>> t = (1, 2)
>>> q = t
>>> t += (3, 4)
>>> t
(1, 2, 3, 4)
>>> q
(1, 2)
```

Be careful when placing mutable objects, such as `lists`, inside tuples. This may lead to very confusing outcomes when changing them. For example:

```
>>> t = (1, 2, 3, [1, 2, 3])
(1, 2, 3, [1, 2, 3])
>>> t[3] += [4, 5]
```

Will **both** raise an error and change the contents of the list within the tuple:

```
TypeError: 'tuple' object does not support item assignment
>>> t
(1, 2, 3, [1, 2, 3, 4, 5])
```

You can use the `+=` operator to "append" to a tuple - this works by creating a new tuple with the new element you "appended" and assign it to its current variable; the old tuple is not changed, but replaced!

This avoids converting to and from a list, but this is slow and is a bad practice, especially if you're going to append multiple times.

Section 28.3: Packing and Unpacking Tuples

Tuples in Python are values separated by commas. Enclosing parentheses for inputting tuples are optional, so the two assignments

```
a = 1, 2, 3 # a is the tuple (1, 2, 3)
```

and

```
a = (1, 2, 3) # a is the tuple (1, 2, 3)
```

are equivalent. The assignment `a = 1, 2, 3` is also called *packing* because it packs values together in a tuple.

Note that a one-value tuple is also a tuple. To tell Python that a variable is a tuple and not a single value you can use

a trailing comma

```
a = 1 # a is the value 1
a = 1, # a is the tuple (1,)
```

A comma is needed also if you use parentheses

```
a = (1,) # a is the tuple (1,)
a = (1) # a is the value 1 and not a tuple
```

To unpack values from a tuple and do multiple assignments use

```
# unpacking AKA multiple assignment
x, y, z = (1, 2, 3)
# x == 1
# y == 2
# z == 3
```

The symbol `_` can be used as a disposable variable name if one only needs some elements of a tuple, acting as a placeholder:

```
a = 1, 2, 3, 4
_, x, y, _ = a
# x == 2
# y == 3
```

Single element tuples:

```
x, = 1, # x is the value 1
x = 1, # x is the tuple (1,)
```

In Python 3 a target variable with a `*` prefix can be used as a [catch-all](#) variable (see Unpacking Iterables):

Python 3.x Version ≥ 3.0

```
first, *more, last = (1, 2, 3, 4, 5)
# first == 1
# more == [2, 3, 4]
# last == 5
```

Section 28.4: Built-in Tuple Functions

Tuples support the following build-in functions

Comparison

If elements are of the same type, python performs the comparison and returns the result. If elements are different types, it checks whether they are numbers.

- If numbers, perform comparison.
- If either element is a number, then the other element is returned.
- Otherwise, types are sorted alphabetically .

If we reached the end of one of the lists, the longer list is "larger." If both list are same it returns 0.

```
tuple1 = ('a', 'b', 'c', 'd', 'e')
tuple2 = ('1', '2', '3')
```

```
tuple3 = ('a', 'b', 'c', 'd', 'e')
```

```
cmp(tuple1, tuple2)
```

```
Out: 1
```

```
cmp(tuple2, tuple1)
```

```
Out: -1
```

```
cmp(tuple1, tuple3)
```

```
Out: 0
```

Tuple Length

The function `len` returns the total length of the tuple

```
len(tuple1)
```

```
Out: 5
```

Max of a tuple

The function `max` returns item from the tuple with the max value

```
max(tuple1)
```

```
Out: 'e'
```

```
max(tuple2)
```

```
Out: '3'
```

Min of a tuple

The function `min` returns the item from the tuple with the min value

```
min(tuple1)
```

```
Out: 'a'
```

```
min(tuple2)
```

```
Out: '1'
```

Convert a list into tuple

The built-in function `tuple` converts a list into a tuple.

```
list = [1,2,3,4,5]
```

```
tuple(list)
```

```
Out: (1, 2, 3, 4, 5)
```

Tuple concatenation

Use `+` to concatenate two tuples

```
tuple1 + tuple2
```

```
Out: ('a', 'b', 'c', 'd', 'e', '1', '2', '3')
```

Section 28.5: Tuple Are Element-wise Hashable and Equatable

```
hash( (1, 2) ) # ok
```

```
hash( ([], {"hello"}) ) # not ok, since lists and sets are not hashable
```

Thus a tuple can be put inside a `set` or as a key in a `dict` only if each of its elements can.

```
{ (1, 2) } # ok
```



```
{ ([], {"hello"}) ) # not ok
```

Section 28.6: Indexing Tuples

```
x = (1, 2, 3)
x[0] # 1
x[1] # 2
x[2] # 3
x[3] # IndexError: tuple index out of range
```

Indexing with negative numbers will start from the last element as -1:

```
x[-1] # 3
x[-2] # 2
x[-3] # 1
x[-4] # IndexError: tuple index out of range
```

Indexing a range of elements

```
print(x[:-1]) # (1, 2)
print(x[-1:]) # (3, )
print(x[1:3]) # (2, 3)
```

Section 28.7: Reversing Elements

Reverse elements within a tuple

```
colors = "red", "green", "blue"
rev = colors[::-1]
# rev: ("blue", "green", "red")
colors = rev
# colors: ("blue", "green", "red")
```

Or using reversed (reversed gives an iterable which is converted to a tuple):

```
rev = tuple(reversed(colors))
# rev: ("blue", "green", "red")
colors = rev
# colors: ("blue", "green", "red")
```

Chapter 29: Basic Input and Output

Section 29.1: Using the print function

Python 3.x Version \geq 3.0

In Python 3, print functionality is in the form of a function:

```
print("This string will be displayed in the output")
# This string will be displayed in the output

print("You can print \n escape characters too.")
# You can print escape characters too.
```

Python 2.x Version \geq 2.3

In Python 2, print was originally a statement, as shown below.

```
print "This string will be displayed in the output"
# This string will be displayed in the output

print "You can print \n escape characters too."
# You can print escape characters too.
```

Note: using `from __future__ import print_function` in Python 2 will allow users to use the `print()` function the same as Python 3 code. This is only available in Python 2.6 and above.

Section 29.2: Input from a File

Input can also be read from files. Files can be opened using the built-in function `open`. Using a `with <command> as <name>` syntax (called a 'Context Manager') makes using `open` and getting a handle for the file super easy:

```
with open('somefile.txt', 'r') as fileobj:
    # write code here using fileobj
```

This ensures that when code execution leaves the block the file is automatically closed.

Files can be opened in different modes. In the above example the file is opened as read-only. To open an existing file for reading only use `r`. If you want to read that file as bytes use `rb`. To append data to an existing file use `a`. Use `w` to create a file or overwrite any existing files of the same name. You can use `r+` to open a file for both reading and writing. The first argument of `open()` is the filename, the second is the mode. If mode is left blank, it will default to `r`.

```
# let's create an example file:
with open('shoppinglist.txt', 'w') as fileobj:
    fileobj.write('tomato\npasta\ngarlic')

with open('shoppinglist.txt', 'r') as fileobj:
    # this method makes a list where each line
    # of the file is an element in the list
    lines = fileobj.readlines()

print(lines)
# ['tomato\n', 'pasta\n', 'garlic']

with open('shoppinglist.txt', 'r') as fileobj:
```

```

# here we read the whole content into one string:
content = fileobj.read()
# get a list of lines, just like int the previous example:
lines = content.split('\n')

print(lines)
# ['tomato', 'pasta', 'garlic']

```

If the size of the file is tiny, it is safe to read the whole file contents into memory. If the file is very large it is often better to read line-by-line or by chunks, and process the input in the same loop. To do that:

```

with open('shoppinglist.txt', 'r') as fileobj:
    # this method reads line by line:
    lines = []
    for line in fileobj:
        lines.append(line.strip())

```

When reading files, be aware of the operating system-specific line-break characters. Although **for line in fileobj** automatically strips them off, it is always safe to call `strip()` on the lines read, as it is shown above.

Opened files (`fileobj` in the above examples) always point to a specific location in the file. When they are first opened the file handle points to the very beginning of the file, which is the position 0. The file handle can display its current position with `tell()`:

```

fileobj = open('shoppinglist.txt', 'r')
pos = fileobj.tell()
print('We are at %u.' % pos) # We are at 0.

```

Upon reading all the content, the file handler's position will be pointed at the end of the file:

```

content = fileobj.read()
end = fileobj.tell()
print('This file was %u characters long.' % end)
# This file was 22 characters long.
fileobj.close()

```

The file handler position can be set to whatever is needed:

```

fileobj = open('shoppinglist.txt', 'r')
fileobj.seek(7)
pos = fileobj.tell()
print('We are at character #%u.' % pos)

```

You can also read any length from the file content during a given call. To do this pass an argument for `read()`. When `read()` is called with no argument it will read until the end of the file. If you pass an argument it will read that number of bytes or characters, depending on the mode (`rb` and `r` respectively):

```

# reads the next 4 characters
# starting at the current position
next4 = fileobj.read(4)
# what we got?
print(next4) # 'cucu'
# where we are now?
pos = fileobj.tell()
print('We are at %u.' % pos) # We are at 11, as we was at 7, and read 4 chars.

fileobj.close()

```

To demonstrate the difference between characters and bytes:

```
with open('shoppinglist.txt', 'r') as fileobj:
    print(type(fileobj.read())) # <class 'str'>

with open('shoppinglist.txt', 'rb') as fileobj:
    print(type(fileobj.read())) # <class 'bytes'>
```

Section 29.3: Read from stdin

Python programs can read from [unix pipelines](#). Here is a simple example how to read from [stdin](#):

```
import sys

for line in sys.stdin:
    print(line)
```

Be aware that `sys.stdin` is a stream. It means that the for-loop will only terminate when the stream has ended.

You can now pipe the output of another program into your python program as follows:

```
$ cat myfile | python myprogram.py
```

In this example `cat myfile` can be any unix command that outputs to stdout.

Alternatively, using the [fileinput module](#) can come in handy:

```
import fileinput
for line in fileinput.input():
    process(line)
```

Section 29.4: Using input() and raw_input()

Python 2.x Version ≥ 2.3

`raw_input` will wait for the user to enter text and then return the result as a string.

```
foo = raw_input("Put a message here that asks the user for input")
```

In the above example `foo` will store whatever input the user provides.

Python 3.x Version ≥ 3.0

`input` will wait for the user to enter text and then return the result as a string.

```
foo = input("Put a message here that asks the user for input")
```

In the above example `foo` will store whatever input the user provides.

Section 29.5: Function to prompt user for a number

```
def input_number(msg, err_msg=None):
    while True:
        try:
```

```

        return float(raw_input(msg))
    except ValueError:
        if err_msg is not None:
            print(err_msg)

def input_number(msg, err_msg=None):
    while True:
        try:
            return float(input(msg))
        except ValueError:
            if err_msg is not None:
                print(err_msg)

```

And to use it:

```
user_number = input_number("input a number: ", "that's not a number!")
```

Or, if you do not want an "error message":

```
user_number = input_number("input a number: ")
```

Section 29.6: Printing a string without a newline at the end

Python 2.x Version \geq 2.3

In Python 2.x, to continue a line with **print**, end the **print** statement with a comma. It will automatically add a space.

```

print "Hello, ",
print "World!"
# Hello, World!

```

Python 3.x Version \geq 3.0

In Python 3.x, the **print** function has an optional **end** parameter that is what it prints at the end of the given string. By default it's a newline character, so equivalent to this:

```

print("Hello, ", end="\n")
print("World!")
# Hello,
# World!

```

But you could pass in other strings

```

print("Hello, ", end="")
print("World!")
# Hello, World!

print("Hello, ", end="<br>")
print("World!")
# Hello, <br>World!

print("Hello, ", end="BREAK")
print("World!")
# Hello, BREAKWorld!

```

If you want more control over the output, you can use `sys.stdout.write`:

```
import sys
```

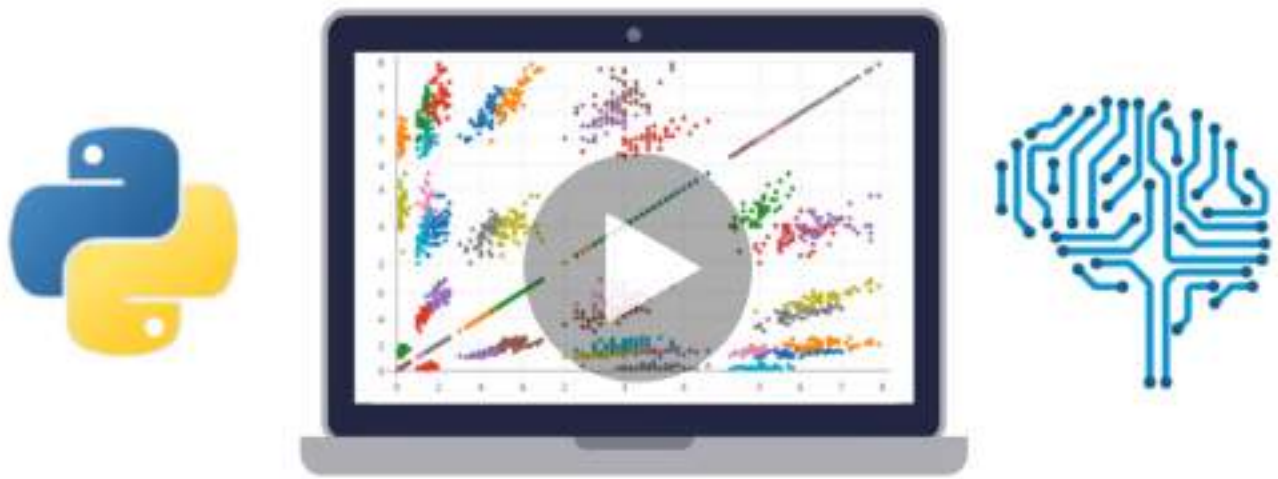
```
sys.stdout.write("Hello, ")
```

```
sys.stdout.write("World!")
```

```
# Hello, World!
```

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Chapter 30: Files & Folders I/O

Parameter	Details
filename	the path to your file or, if the file is in the working directory, the filename of your file
access_mode	a string value that determines how the file is opened
buffering	an integer value used for optional line buffering

When it comes to storing, reading, or communicating data, working with the files of an operating system is both necessary and easy with Python. Unlike other languages where file input and output requires complex reading and writing objects, Python simplifies the process only needing commands to open, read/write and close the file. This topic explains how Python can interface with files on the operating system.

Section 30.1: File modes

There are different modes you can open a file with, specified by the `mode` parameter. These include:

- `'r'` - reading mode. The default. It allows you only to read the file, not to modify it. When using this mode the file must exist.
- `'w'` - writing mode. It will create a new file if it does not exist, otherwise will erase the file and allow you to write to it.
- `'a'` - append mode. It will write data to the end of the file. It does not erase the file, and the file must exist for this mode.
- `'rb'` - reading mode in binary. This is similar to `r` except that the reading is forced in binary mode. This is also a default choice.
- `'r+'` - reading mode plus writing mode at the same time. This allows you to read and write into files at the same time without having to use `r` and `w`.
- `'rb+'` - reading and writing mode in binary. The same as `r+` except the data is in binary
- `'wb'` - writing mode in binary. The same as `w` except the data is in binary.
- `'w+'` - writing and reading mode. The exact same as `r+` but if the file does not exist, a new one is made. Otherwise, the file is overwritten.
- `'wb+'` - writing and reading mode in binary mode. The same as `w+` but the data is in binary.
- `'ab'` - appending in binary mode. Similar to `a` except that the data is in binary.
- `'a+'` - appending and reading mode. Similar to `w+` as it will create a new file if the file does not exist. Otherwise, the file pointer is at the end of the file if it exists.
- `'ab+'` - appending and reading mode in binary. The same as `a+` except that the data is in binary.

```
with open(filename, 'r') as f:
    f.read()
with open(filename, 'w') as f:
    f.write(filedata)
with open(filename, 'a') as f:
    f.write('\n' + newdata)
```

	r	r+	w	w+	a	a+
Read	✓	✓	✗	✓	✗	✓

Write	x	✓	✓	✓	✓	✓
Creates file	x	x	✓	✓	✓	✓
Erases file	x	x	✓	✓	x	x
Initial position	Start	Start	Start	Start	End	End

Python 3 added a new mode for exclusive creation so that you will not accidentally truncate or overwrite an existing file.

- 'x' - open for exclusive creation, will raise `FileExistsError` if the file already exists
- 'xb' - open for exclusive creation writing mode in binary. The same as x except the data is in binary.
- 'x+' - reading and writing mode. Similar to w+ as it will create a new file if the file does not exist. Otherwise, will raise `FileExistsError`.
- 'xb+' - writing and reading mode. The exact same as x+ but the data is binary

	x	x+
Read	x	✓
Write	✓	✓
Creates file	✓	✓
Erases file	x	x
Initial position	Start	Start

Allow one to write your file open code in a more pythonic manner:

Python 3.x Version \geq 3.3

```
try:
    with open("fname", "r") as fout:
        # Work with your open file
except FileExistsError:
    # Your error handling goes here
```

In Python 2 you would have done something like

Python 2.x Version \geq 2.0

```
import os.path
if os.path.isfile(fname):
    with open("fname", "w") as fout:
        # Work with your open file
else:
    # Your error handling goes here
```

Section 30.2: Reading a file line-by-line

The simplest way to iterate over a file line-by-line:

```
with open('myfile.txt', 'r') as fp:
    for line in fp:
        print(line)
```

`readline()` allows for more granular control over line-by-line iteration. The example below is equivalent to the one above:

```
with open('myfile.txt', 'r') as fp:
    while True:
        cur_line = fp.readline()
```

```
# If the result is an empty string
if cur_line == '':
    # We have reached the end of the file
    break
print(cur_line)
```

Using the for loop iterator and `readline()` together is considered bad practice.

More commonly, the `readlines()` method is used to store an iterable collection of the file's lines:

```
with open("myfile.txt", "r") as fp:
    lines = fp.readlines()
for i in range(len(lines)):
    print("Line " + str(i) + ": " + line)
```

This would print the following:

```
Line 0: hello
```

```
Line 1: world
```

Section 30.3: Iterate files (recursively)

To iterate all files, including in sub directories, use `os.walk`:

```
import os
for root, folders, files in os.walk(root_dir):
    for filename in files:
        print root, filename
```

`root_dir` can be `"."` to start from current directory, or any other path to start from.

Python 3.x Version ≥ 3.5

If you also wish to get information about the file, you may use the more efficient method [os.scandir](#) like so:

```
for entry in os.scandir(path):
    if not entry.name.startswith('.') and entry.is_file():
        print(entry.name)
```

Section 30.4: Getting the full contents of a file

The preferred method of file i/o is to use the `with` keyword. This will ensure the file handle is closed once the reading or writing has been completed.

```
with open('myfile.txt') as in_file:
    content = in_file.read()

print(content)
```

or, to handle closing the file manually, you can forgo `with` and simply call `close` yourself:

```
in_file = open('myfile.txt', 'r')
content = in_file.read()
print(content)
```

```
in_file.close()
```

Keep in mind that without using a **with** statement, you might accidentally keep the file open in case an unexpected exception arises like so:

```
in_file = open('myfile.txt', 'r')
raise Exception("oops")
in_file.close() # This will never be called
```

Section 30.5: Writing to a file

```
with open('myfile.txt', 'w') as f:
    f.write("Line 1")
    f.write("Line 2")
    f.write("Line 3")
    f.write("Line 4")
```

If you open `myfile.txt`, you will see that its contents are:

```
Line 1Line 2Line 3Line 4
```

Python doesn't automatically add line breaks, you need to do that manually:

```
with open('myfile.txt', 'w') as f:
    f.write("Line 1\n")
    f.write("Line 2\n")
    f.write("Line 3\n")
    f.write("Line 4\n")
```

```
Line 1
Line 2
Line 3
Line 4
```

Do not use `os.linesep` as a line terminator when writing files opened in text mode (the default); use `\n` instead.

If you want to specify an encoding, you simply add the encoding parameter to the `open` function:

```
with open('my_file.txt', 'w', encoding='utf-8') as f:
    f.write('utf-8 text')
```

It is also possible to use the `print` statement to write to a file. The mechanics are different in Python 2 vs Python 3, but the concept is the same in that you can take the output that would have gone to the screen and send it to a file instead.

Python 3.x Version ≥ 3.0

```
with open('fred.txt', 'w') as outfile:
    s = "I'm Not Dead Yet!"
    print(s) # writes to stdout
    print(s, file = outfile) # writes to outfile
```

*#Note: it is possible to specify the file parameter AND write to the screen
#by making sure file ends up with a None value either directly or via a variable*

```
myfile = None
print(s, file = myfile) # writes to stdout
print(s, file = None)  # writes to stdout
```

In Python 2 you would have done something like

Python 2.x Version ≥ 2.0

```
outfile = open('fred.txt', 'w')
s = "I'm Not Dead Yet!"
print s      # writes to stdout
print >> outfile, s  # writes to outfile
```

Unlike using the write function, the print function does automatically add line breaks.

Section 30.6: Check whether a file or path exists

Employ the [EAFP](#) coding style and `try` to open it.

```
import errno

try:
    with open(path) as f:
        # File exists
except IOError as e:
    # Raise the exception if it is not ENOENT (No such file or directory)
    if e.errno != errno.ENOENT:
        raise
    # No such file or directory
```

This will also avoid race-conditions if another process deleted the file between the check and when it is used. This race condition could happen in the following cases:

- Using the `os` module:

```
import os
os.path.isfile('/path/to/some/file.txt')
```

Python 3.x Version ≥ 3.4

- Using `pathlib`:

```
import pathlib
path = pathlib.Path('/path/to/some/file.txt')
if path.is_file():
    ...
```

To check whether a given path exists or not, you can follow the above EAFP procedure, or explicitly check the path:

```
import os
path = "/home/myFiles/directory1"

if os.path.exists(path):
    ## Do stuff
```